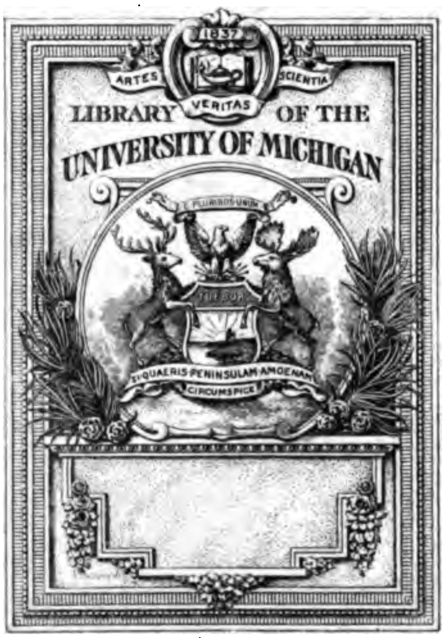
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THE

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AND

ALLIED SCIENCES

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CONTENTS.

JULY NUMBER.

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Errata for Vol. XIX.

Page 399, line 17, for "youngest of," read young of.

Page 406, line 18, "*Olenoides*" should be *Olenelloides*, and the same change should be made in the footnote at the bottom of the page. This Scotch genus is the one referred to at p. 404, line 3. The resemblance in appearance of this name to Olenoides is misleading; but Olenoides is Middle Cambrian, and a synonym of Dorypyge.

Page 407, line 2. Reverse the reference to the comparative abundance of *A. brevifrons* and *A. parvifrons*.

Errata for Vol. XX.

Page 44, line 21, for "13, 14, 21 and 23," read 14, 15, 22 and 23.

Page 53, line 6 from the bottom, for "percolating lime," read chloride of lime.

Page 83, line 15, for "biographical" read bibliographic.

Page 84, line 7, for "China" read Chili.

Page 86, line 18, for "claim" read claims.

Page 88. After line 14, insert "First Report on the Geology of the Public Lands of the State of Maine. Senate No. 89. Boston, 1837, pp. 47."

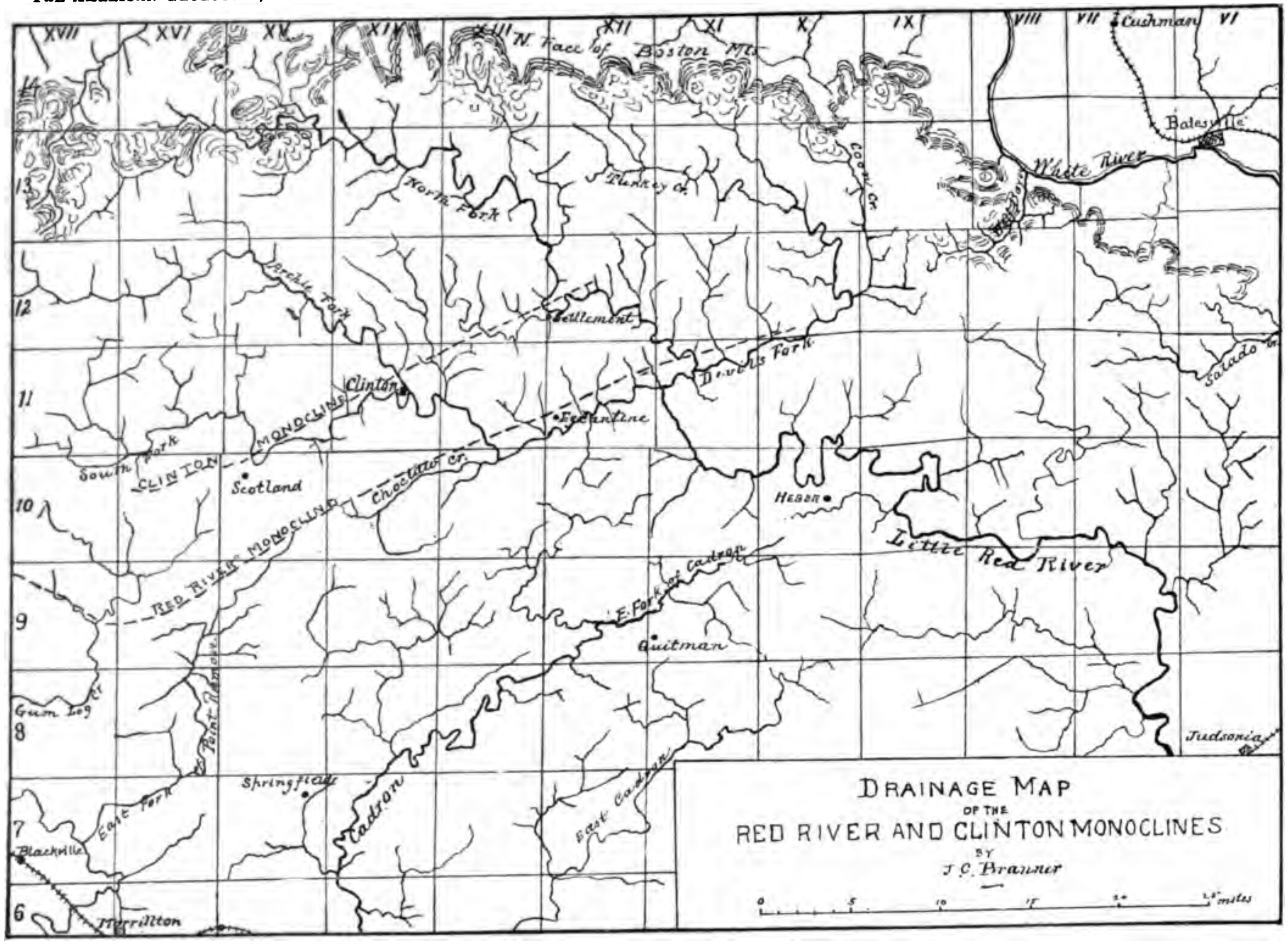
Page 96, line 15, for "liv" read iv.

Page 106, line 8 from the bottom, for "on" read of.

Page 110, line 7, for "Morion" read Marion.

Page 201, line 21 from the bottom, for "metres" read miles.

Page 320, line 9, for "chronologique" read géologique.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THE

AMERICAN GEOLOGIST.

VOL. XX. JULY, 1897. No. 1

THE RED RIVER AND CLINTON MONOCLINES, ARKANSAS.

By JOHN F. NEWSOM, Univ. of Ind., Bloomington.
With an introduction by JOHN C. BRANNER.

(PLATE I.)

Introduction.

During the progress of the late geological survey of Arkansas I became interested in the peculiar drainage about the eastern end of the Boston mountains, the parallelism of some of the streams, the similarity of certain of their elbows, the angles they make with certain other streams, and the relations of these streams to certain structural features of adjacent regions with whose geology I was acquainted. In order to ascertain the relations of the geologic structure to the drainage, professor J. F. Newsom, then one of the assistants of the geological survey, now professor of geology in the University of Indiana, was directed to work out the geology along what is described in the present paper as the Red river and the Clinton monoclines.

It was found that the northeast-southwest directions of Little Red river and its tributaries are due to these monoclinal folds. It is an interesting fact that the Red river fold is in the axis of Wolf bayou which flows into White river, and that this line of disturbance passes north of Dean mountain, crosses White river four miles above Batesville, crosses Polk

bayou a mile north of Batesville, crosses Miller creek four miles northeast of Batesville, and disappears about a mile north of Sharp's Cross Roads, in Independence county. It is thus traceable about seventy miles in a nearly straight line.

The upper course of the East fork of Cadron creek lies for twenty-five miles in a course parallel to these monoclines. The upper part of this stream, from east of Quitman to where it bends southward south-east of Springfield, flows along the bottom of a low synclinal trough. The small parallel stream in 8 N., 13 and 14 W., flows behind the ridge made by beds that dip beneath this syncline. The lower part of Salado creek to the northeast has about fifteen miles of its course in the same line approximately.

In connection with the northwest-southeast courses of the drainage of this region I would call attention to the fact that these streams are approximately parallel to certain escarpments of the north face of the Boston mountains, notably that between Wolf bayou and Mountain View. Adjoining this region north of the Boston mountains there are also some gentle folds and faults.

The bearings of a few of these intersecting structural lines are here brought together.

Northwest-Southeast Lines.

	Bearing.	Length.
Cow mountain—Round mountain syncline	S. 65° E.	15 miles
Fault ¾ mile south of Round mountain	S. 63° E.	12 "
General course of South Sylamore creek	S. 62° E.	14 "
General course of North Sylamore creek	S. 58° E.	15 "
General course of Livermore creek	S. 62° E.	8 "
Rush creek fault, Marion county	S. 65° E.	4 "
Turkey creek, the north fork of Little Red river.	S. 45° E.	20 "
Middle fork of Little Red river	S. 58° E.	30 "
Archie fork of Little Red river	S. 53° E.	20 "
Red river monocline west of Gum Log creek...	S. 63° E.	15 "
Boston mountains northwest of Wolf bayou...	S. 51° E.	12 "

Northeast-Southwest Lines.

Des Arc ridge, northwest of Searcy	N. 60° E.	9 "
Axis Blackville syncline east of Greenbrier....	N. 62° E.	9 "
Red river monocline	N. 67° E.	40 "
Red river, Devil's Fork and Choctaw creek....	N. 67° E.	30 "
Clinton monocline	N. 62° E.	26 "
East fork of Cadron creek	N. 60° E.	25 "
Fault northeast and southwest of St. Joe..	N. 45°-50° E.	24 "

Many other minor cases of parallelism of the drainage lying in these two general directions may be seen on a drainage map, but they need not be mentioned here. Attention, however, should be called to the fact that there seems to be two other systems of joints in the area here especially considered: one running north-south, the other east-west.

The structural features explain the drainage in some of these cases and in such cases it seems clear that the drainage is consequent and hence is very old, having come down from the close of the Carboniferous or of the Permian.* A short way south of the region of the Red river monocline and south of that part of Cadron creek that flows parallel to the Red river monocline, the relation of the drainage to the structure is not so clear. Here the streams cut across considerable ridges, and for the most part, appear to disregard them. This area, however, is lower than that of the Red river monocline, and is adjacent to the Cretaceous and Tertiary area lying south and east. From township 7 North, southward and eastward, the drainage in some cases follows structural lines, such as Cypress creek, Little Cypress creek and Muddy bayou, all of which flow along synclinal valleys. In other cases, however, the drainage cuts square across the axes; such are Bayou Meto, parts of Cadron creek, both East and West forks, and Jack's bayou north of Jacksonville. The question is therefore suggested whether or not this may be a superimposed drainage.

Along the adjoining Tertiary area to the east the Tertiary beds are at a lower level than the paleozoic highlands, but at Little Rock the Tertiary beds have an elevation of 380 feet above tide on top of Capitol hill, several points in the city are 360 feet, and elevations of 350 are quite common in the city and vicinity. Southwest of Little Rock the Tertiary beds reach an elevation of more than 500 feet above tide level four miles northeast of Benton, and on Sand mountain east of Bryant and southeast of Alexander they reach over 600 feet. A general and even subsidence that would bring these points

*A most valuable paper on the subject of joints and faults in their relation to drainage is that of Daubrée: Cassures imitant les failles et les joints congénères, dans leur formes, leur parallélisme, etc. on pp. 300-374 of his Études Synthétiques de Géologie Expérimentale, Paris, 1879.

beneath the water would also submerge the whole of the region between Little Rock and Conway or Morrillton and the region somewhat north of Springfield in Conway county, which has an elevation of 420 feet above tide level. Only two or three small points would be left above water by such a submergence. It seems probable therefore that the Tertiary beds once overlapped the Lower Coal Measures rocks to a point near Springfield, Conway county, and that when these beds emerged their drainage was let down upon the underlying Lower Coal Measures rocks.

A fact of interest in connection with the denudation of this area is that while it stood at least 500 feet lower during Tertiary times, it was subsequently elevated so that it stood higher than it does at present. Evidences of this later elevation may be seen at a great many points between Little Rock and Fort Smith, but it will be enough to mention a couple of illustrations of the nature of the evidence. About two miles northeast of Argenta the drainage of Dark Hollow and of several hollows that converge near its mouth falls into a flat country that has an area of several square miles. The topography of the sides of these hollows is steep from near the hill tops, and at the bottom of the hills the slopes seem to dive beneath the river bottoms. This plunging of a steep hill-side beneath bottom lands, as if they were silted up fiords, is to be seen at a great many places north and west of Little Rock: at the northwest and the southeast bases of Big Rock; north of the bluffs three miles up the river from Little Rock; at the Maumelle Pinnacles, especially on the north side; on Palarm bayou, at Petit Jean mountain, etc. Such a state of affairs must have been produced by a subsidence and checking of the drainage and silting up of the valleys after the steep sided V-shaped valleys had been cut down.

JOHN C. BRANNER.

THE RED RIVER MONOCLINE.

Beginning south of White river in the deep ravine of Wolf bayou, about twelve miles above Batesville, the course of the Red river disturbance will be traced to where it swings toward the northwest, in the northern edge of Conway county.

Four miles southwest of Dean mountain the sandstones of

Wolf bayou are sharply folded at some places, and there are unmistakable evidences of faulting, but on account of the similarity of the different beds through the locality it is impossible to tell the extent of the slip.

About 250 yards south of the south half-mile corner of section 33, 13 N., 8 W., in the hillside east of the small creek is the hanging wall of a fault at the north side of the slip. The slip is probably not very extensive. The down-throw is on the north side. North of the fault the sandstones have a north dip of 25°: south of it the strata are nearer horizontal.

In 12 N., 10 W., section 33, the south half, two and one-half miles above Wilson's ford, in the valley of Devil's Fork of Little Red river, the sandstones have a dip of 15°–20° southward and are slightly faulted. The down-throw is on the south side. The displacement is probably not more than 40 or 50 feet. Although the connection between the fault at this place and that observed on Wolf bayou, to the northeast, has not been traced out, there is but little doubt that the two are the result of the same forces.

From section 33 to the southwest the rock beds are folded in the axis of the monocline which extends parallel with Devil's Fork, and is just north of it; the strata dip sharply to the south from the high plateau of the Boston mountains. Along Devil's Fork the strata are sometimes slightly faulted near the axis of the fold.

In 11 N., 11 W., section 10, the northwest quarter, the axis of the monocline crosses Hell creek one-fourth of a mile above its mouth. The strata are faulted at this place: immediately south of the fracture they have a dip of 8° south, 25° east, while a short distance to the north the dip becomes gentler. (Fig 1.) The hanging wall of the fault is on the south side of the slip and has a dip of 55°, south 10° west. The amount

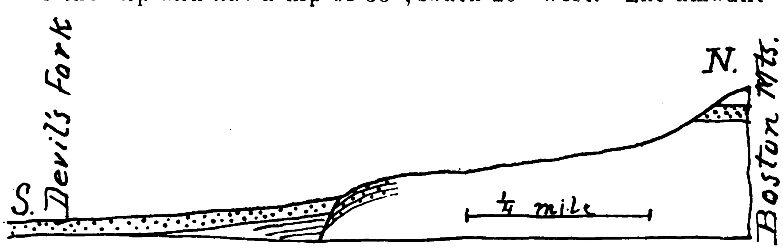

FIGURE 1.

of displacement cannot be ascertained, but it is probably not very great, the elevation of the strata forming the mountains to the north being due to the monoclinal fold, rather than to the displacement by faulting.

From Hell creek the monoclinal axis continues to the southwest, parallel to the general course of Red river, and from one-half mile to one mile to the north of that stream. In 11 N., 11 W., it passes through the northwest quarter of section 10, just north of the center of section 9, through the south half of section 8, and just north of the north half-mile corner of section 18. This is one-fourth of a mile north of Kinderhook postoffice, at which place the strata have a dip of about 15° a little east of south.

In 11 N., 12 W., the axis of the fold passes near the center of section 14. One hundred yards north of the center of the northeast quarter of the southeast quarter of this section the beds are faulted, the down-throw being slight, and on the south side. Where the public road crosses a small creek south of the center of the southeast quarter of section 20, just south of Mr. Bradford's house, the flaggy sandstones at the south side of the monoclinal fold are seen dipping beneath the bottom land of Red river at an angle of 20°, south 20° east. The dips become gentler toward the north and at the center of the northeast quarter of section 20 the strata are flat. There is no fault near the monoclinal axis at this place. The rocks south of the river in this region lie approximately flat as seen in the rocks capping Sugar Loaf mountain and in the sandstones east of it.

The accompanying section (fig. 2) from the top of Sugar Loaf mountain running north across the monoclinal axis shows the relations of the sandstones capping this mountain to the sandstones forming the high hills to the northward.

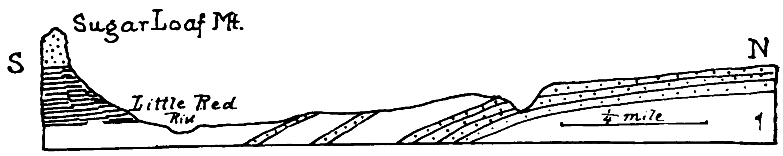

FIGURE 2.

The axis of the fold passes immediately north of Eglantine, which town is in 11 N., 12 W., at the center of section 30.

The sandstone beds in this locality dip beneath Red river, and beneath the high sandstone capped escarpment that is immediately south of it.

In 11 N., 13 W., the fold passes through the south half of 25, the north half of 35, and through the center of section 34. In sections 25 and 35 the beds at some places have a southward dip of 40–75 degrees, and show strong evidences of a fault.

Red river coming from the north cuts through the fold in the south half of section 34. The dips southwest of this point are not as steep as in the vicinity of Eglantine, ranging only from 4 to 18 degrees south. Choctaw creek runs parallel to the fold and either entirely at the south side of it or cutting through the tilted strata. In the vicinity of Choctaw postoffice while the strata do not dip so sharply to the south, the monocline is broader. All the strata in the hills to the north of Choctaw creek pass beneath those that form the high escarpment south of that creek. This escarpment is but a continuation of that seen south of Red river and farther east. The fold passes through 10 N., 14 W., from section 1 to section 19, with dips of 10–15 degrees south 15–20 degrees east. From the northeast corner of 10 N., 14 W., the fold extends in an almost direct line to the northwest quarter of section 21, 9 N., 16 W. The strata dipping from 10 to 20 degrees, south 10 to 20 degrees east, and passing beneath the beds of the escarpment to the south, this escarpment is the western extension, more or less prominent, of the high escarpment south of Red river in the vicinity of Eglantine.

In 9 N., 16 W., sections 14, 15, 21, 20 and 19, the fold is by no means well marked, the strata having dips not steeper than 5–10 degrees. In sections 21 and 20 the beds instead of having a slightly southeast dip have a due south dip, the strike being east and west, One mile south of Cleveland, in section 20, the center of the southeast quarter, the beds have a dip of 8 degrees south.

Just north of the center of section 20, the monoclinal axis reaches its southernmost point, turning from this place gently towards the northwest. In 9 N., 17 W., section 15, near the southeast corner, the strata are very much disturbed and have the appearance of being faulted. with the line of slip at right

angles to the axis of the monocline. Although the dips in this locality are very confusing, the fold may be readily traced to the northwest, leaving 9 N., 17 W., at the west line of section 6, south of White Oak mountain. At this place the strata have southward dips of 15–20 degrees. From this point westward to its western terminus the fold is parallel to the south face of the Boston mountains, the axis being close to the mountain escarpment which is very prominent everywhere from White Oak mountain in 10 N., 18 W., to Mulberry mountain in 10 N., 20 W.

From south of White Oak mountain the monocline extends to the northwest to the west side of 10 N., 18 W., where in sections 18 and 19, south and southwest dips, at some places 20 degrees, are to be seen. The direction of the fold from the west side of 10 N., 18 W., is slightly south of west for six miles, the dips ranging from 10–20 degrees, southward. From the northwest quarter of section 30 it turns directly to the northwest, striking the west range line of 10 N., 20 W., in section 7, from which point it continues in a direction slightly north of west to 11 N., 21 W., section 30, the southwest quarter, where it turns to an almost west direction which it continues to 11 N., 24 W., section 30, the southwest quarter, where the rocks dip 15–20 degrees south. Here the fold turns again to the southwestward around the south base of Mulberry mountain and has its western terminus at a distinct fold just south of the western end of that mountain in 10 N., 26 W.

The axis of this line of disturbance is, in a general way, parallel to the principal axes of folding in the mountains between it and the north side of the Ouachita uplift.

Effects upon Drainage and Topography. One of the most noticeable features of the Red River monocline is its effect upon the drainage and topography of the country through which it passes. Owing to the slight resistance offered to erosion along the line of disturbance the streams have cut out deep valleys parallel to it. The axis of the fold is always found a short distance (from one-half mile to one mile) to the north of the present location of the streams, which are in the south dipping rocks. The original course of the streams must have been in each case at the axis of the fold or where

faulted at the line of the slip, but owing to subsequent erosion as the streams have cut downward they have been moved southward along the bedding planes to their present positions. This is true of all the streams along the fold from the south side of White river, in Independence county, to the center of township 9 N., 17 W., with the exception of Wolf bayou, which has its source in 12 N., 9 W., and flows northeast very near the axis of disturbance, sometimes crossing it, until the stream turns to the north to enter White river. The Devil's Fork of Little Red river, however, follows the rule, flowing from its source in 14 N., 12 W., to the southeast until it reaches the south side of the fold in 12 N., 10 W. Here it turns directly to the southwest, and runs parallel to the fold as far as the west side of 11 N., 11 W. Little Red river flowing from the northwest crosses the axis in 11 N., 13 W., section 33. One mile south of this it turns northeast and continues parallel to the fold to where it turns to the southeast at the mouth of Devil's Fork.

Choctaw creek, with its source near the axis of the fold in 10 N., 14 W., flows northeast its whole length at the south side of that axis, and enters Little Red river where that river turns to the northeast.

South of Eglantine is a very bold escarpment at the south side of the river. This escarpment rises 700 feet above the valley and is the most prominent topographic feature of the locality. It is capped with a massive sandstone bed which has a general dip to the southwest, owing to which the escarpment becomes lower in that direction. Beneath the thick sandstone cap is a thick bed of shale; the breadth of the valley in the vicinity of Eglantine is due to the wearing away of this shale bed. Sugar Loaf mountain, in section 28, the northwest quarter, is a high sandstone capped peak with shale at its base. It is simply an outlier of the escarpment to the southwest from which it has been separated by erosion. From the northwest its appearance is that of a truncated cone. The sandstone cap at the top is flat.

The mountains to the north of Choctaw creek and Little Red river, though high and rugged, are not so prominent as is the escarpment to the south. The strata forming the mountains

north of the river are all carried beneath the shales of the high escarpment to the south by the monoclinal fold.

The East Fork of Point Remove creek has its source near the monocline in 10 N., 15 W., and flows to the southwest and parallel to it for ten miles where it is entered by a small stream flowing from the southwest. Rock creek, which enters Point Remove creek, in 9 N., 17 W., near the east line of section 33, comes from the northwest along the line of disturbance.

The Red river monocline at the south combined with the Clinton monocline at the north, with its corresponding low syncline, forms a broad, low anticline between these two folds. The accompanying north-south section from the south face of the Boston mountains, at Scotland, to the Red river monocline will make this clear.

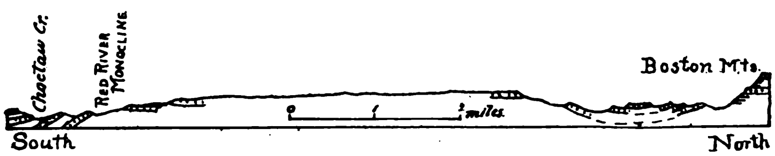

FIGURE 3.

This low anticlinal fold is more marked at its western extremity than at its eastern. The position of the south face of the main range of the Boston mountains is materially effected by these two monoclines with their accompanying anticline. From the vicinity of the mouth of Devil's fork in 11 N., 11 W., the south face of the mountain retreats, though not abruptly, in a northwest direction to the vicinity of Settlement postoffice, from which place the main range lies to the northward of the Clinton monocline* to the western extremity of that fold. Here the face of the mountains turns to the southwest as far as White Oak mountain. From White Oak mountain westward the Red river monocline has not the effect on the course of the streams that is noticed at its eastern end, but its effect on the topography of the country is even more marked.

All of that portion of the range from White Oak mountain, in the northeast corner of 9 N., 18 W., to Mulberry mountain,

*See accompanying description of Clinton monocline.

in the northeast corner of 10 N., 26 W., owes its elevation to this monocline. Through this region it is almost everywhere a breached fold, leaving the south face of the mountains, which have an elevation above the valleys of 800 to 1,500 feet, standing out abruptly in bold relief above the country to the south.

The monocline is accompanied by a corresponding shallow syncline more or less continuous at its south side. The south dipping sandstones usually form parallel ridges, the shales between the sandstone beds forming the valleys. The ridges are seldom of much prominence and are never continuous for a great distance.

The mountain escarpment to the north of the fold has at its top massive sandstone beds often forming vertical cliffs 100 feet high. These beds are repeated in low ridges at the south side of the monoclinal fold, and are usually from one-half mile to one mile south of the mountain escarpment. There is a very prominent sandstone cliff in the south face of the mountains through townships 11 N., 23, 24 and 25 W. The sandstone bed that forms this cliff comes low in the base of Mulberry mountain, owing to the dying away of the monoclinal fold to the south. This bed repeated at the south side of the monocline forms the most prominent of several low east-west ridges formed by the south dipping sandstones, through the north part of these townships.

This ridge is continuous, except where gaps are cut through by the southward flowing streams, from 11 N., 23 W., section 31, the south half, to 10 N., 26 W., section 16, the north half. The dip of the sandstone bed forming it is 20–25 degrees south, becoming nearer horizontal at its western end where the monocline dies out. This sandstone bed forms the floor of the Philpott coal basin, which belongs to the upper coal bearing division of Winslow.*

The syncline that forms this basin is the western representative of the syncline that is seen to the south of the monoclinal fold farther east.

The Clinton monocline. The Clinton monocline is very similar to the Red River monocline, described above, except

* Preliminary Report on Coal, Arkansas Geol. Surv. Annual Report for 1888. Vol. III, p. 33.

that it is not so long and the fold is not so sharp. Its eastern termination as a well marked fold is in 12 N., 12 W., section 15, not far east of Indian creek. In this region it is not a prominent feature, the strata dipping to the southward at angles of only 8–10 degrees.

The fold which is by no means well marked runs from section 15 to the southwest, parallel to the Middle Fork of Red river and is cut by that river three-fourths of a mile north of Settlement postoffice. At this place the strata in the bluff at the west side of the river dip 15 degrees southward, and are apparently slightly faulted.

The low south dips continue to the southwest. The axis of disturbance is cut by Archie's fork of Red river a mile north of Clinton, in 11 N., 14 W., section 10, the southeast quarter, at which place the beds dip 10–12 degrees south and are faulted, though the amount of displacement is probably not more than 15–20 feet. This fault may be seen in the sandstone bluff at the east side of the river one mile north of Clinton.

From Clinton the fold continues to the southwest to Scotland. Just north of Scotland the strata have south dips of 10–12 degrees. The axis of the fold extends from 10 N., 15 W., near the southwest corner of section 5, to 10 N., 16 W., the west half-mile corner of section 1, from which place it turns slightly towards the south as far as the northwest quarter of section 16. There turning again to the westward to sections 17 and 18 where the dip becomes so low that it can no longer be traced and where it looses its effect upon the topography.

Effect on the topography of the country. By tracing on the map the direction of the axis of the Clinton monocline and comparing with the direction of the Red river monocline, to the south, it will be seen that they are from 6 to 8 miles apart and approximately parallel. Though the northernmost of these two folds is at no place very sharp, its effect upon the drainage and topography is quite marked. From near Settlement postoffice in 12 N., 12 W., to its western end in 10 N., 16 W., it marks very closely the southern face of the main range of the Boston mountains (the mountains to the south being more properly outliers of the main range than belong-

ing to it), though it is only north and west from Scotland that that face stands out in bold relief above the country to the south. Around the western end of the fold the southern mountain escarpment turns irregularly to the southwest to White Oak mountain in Pope county which mountain owes its elevation to the Red river monocline.

The sudden turn of Middle fork at Settlement postoffice is due to this fold as is also the northeast course of Weaver creek west of Settlement postoffice, and the course of South fork of Red river from Scotland to Clinton.

In the neighborhood of Scotland and west of that place there are several more or less prominent ridges made by the tilted sandstones at the south side of the fold. Here there is also a small syncline of which these ridges with the south dipping beds form the north side (see fig. 3).

SECONDARY OCCURRENCES OF MAGNETITE ON ISLANDS OF BRITISH COLUMBIA BY REPLACEMENT OF LIMESTONE AND BY WEATHERING OF ERUPTIVES.

By JAMES P. KIMBALL, New York.

(Plates II and III.)

The present paper is designed as a continuation of publications in the year 1891.* The occurrences here referred to clearly conform to two separate types of ferriferous deposits which it has seemed important to distinguish as hydro-chemical replacements. As previously described, one type is a morphological replacement of limestone by double decomposition between ferrous salts and calcic carbonate, the former being generated from ferrous silicates; the other type, a partial, and not necessarily pseudomorphic, replacement of ferrous silicates in weathered basic rocks, or as more explicitly distinguished, a residual concentration or fixation of iron oxides incidental to development of soluble alkaline carbonates from weathering oxidation or splitting up of ferriferous silicates. In replacements of limestone ferriferous material is generally derived from extraneous though contiguous sources through simple permutations and reactions which I have elsewhere followed out.

*Am. Jour. Sci., XLII, 231; AM. GEOLOGIST, VIII, 352.

In replacement of pyroxenic and lime-feldspar rocks of the greenstone family, like diorite, diabase, gabbro, etc., and other basic rocks, whether metamorphic or intrusive, residual concentration or fixation of stable iron oxides is brought about through initial decomposition of ferrous and ferric silicates, chiefly the former, whence development of soluble alkaline carbonates along with ferrous salts, whence again spontaneous double decomposition, and finally isolation of insoluble residues. This cyclus or process of weathering action is obviously regenerative.

Secondary occurrences of the kind referred to have come to be described in general terms as differentiations of iron oxides not only in concrete ore bodies of irregular or lenticular form between divisional surfaces of eruptive masses as well as of terranes, but also in graduations of rock into ferriferous aggregations. The same term however as applied to primary concentrations of highly basic products in eruptive rocks, as may easily be conceived, is by some writers (Brögger, Vogt, and others) even made to imply isolation of magnetite as a mode of development of certain ore-bodies from cooling magmas. An objection of weight to a theory of this kind arises from the invariable instability of basic rocks of all ages, and from their profound alteration by hydro-chemical molecular or atomic rearrangement, involving all constituents.

In replacements of pyroxenic rocks whether superficial or under cover an environment of limestone, even where no bodily replacement of limestone has occurred, is so common as to have a significance beyond mere coincidence, and for obvious reasons. Equally significant is the notable presence of lime, sometimes as a carbonate, in basic crystalline aggregates, like diorite, dolerite, diabase, gabbro, etc.,—most subject to alteration, and, in physical circumstances favorable for preservation of such secondary deposits, the particular repositories of ferriferous concentrations.

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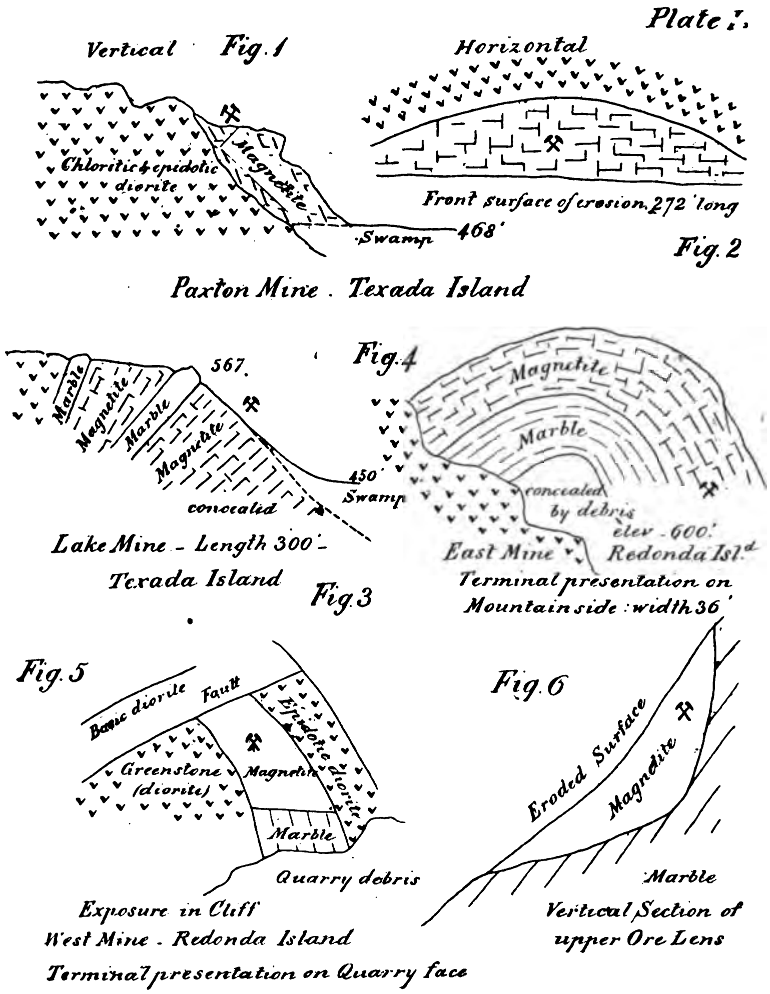
Plate
Vertical
Fig. 1
Horizontal
Chloritic & epidotic diorite
Magnetite
Swamp
468'
Front surface of erosion, 272' long
Fig. 2
Paxton Mine. Texada Island
567.
Marble
Magnetite
Marble
Magnetite
450'
Swamp
concealed
Lake Mine - Length 300'-
Texada Island
Fig. 3
Fig. 4
Magnetite
Marble
concealed by debris
elev. 600'.
East Mine
Redonda Isl.d
Terminal presentation on Mountain side: width 36'
Fig. 5
Basic diorite
Fault
Epidotic diorite
Greenstone (diorite)
Magnetite
Marble
Quarry debris
Exposure in Cliff
West Mine - Redonda Island
Terminal presentation on Quarry face
Fig. 6
Eroded Surface
Magnetite
Marble
Vertical Section of upper Ore Lens

ognize in secondary anfractuosities from contraction and expansion of the mass incidental to hydro-chemical mutations, and again in such as subsist between divisional surfaces of all other kinds, especially when acted upon by corrosive solutions in secular transmission. From another point of view, such *loci* of deposition whether macroscopically or microscopically considered, are virtually determined by mechanical conditions of least resistance as effected by both chemical and physical forces operating alternately or together and developed one from the other. Not least among these correlative forces to be recognized are molecular or concretionary attraction of the mass for homologous matter in passing solutions, or even in suspension; or, as I have elsewhere used the term, the extra-molecular tendency of ochreous material to form concretions or aggregations.*

Union of magnetite molecules is doubtless promoted also by polarity. Incidentally to common secular weathering of basic rocks, the chemical forces brought into play are easily perceived to be mainly through simple alternating and regenerative reactions in which atmospheric oxygen and carbonic acid take the lead. In a valuable contribution to the study of this subject, Mr. J. E. Spurr has partially traced with much minuteness the cyclus of physical and chemical operations concerned in the isolation and fixation of ferriferous oxides from basic rocks.†

Secondary ore deposits of the types above referred to were instanced by me in the year 1884, as illustrated by important occurrences on the south shore of the island of Cuba, between the bays of Santiago and Guantanamo.‡ Numerous geologists (Pumpelly, Van Hise, the Messrs. Winchell, and others)

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*Am. Jour. Sci., XLII, 240.

†Geol. Surv. Minn., Bull. x, Chapters vi and ix. *Vid.* Senft. Min., 1875, p. 502.

Changes, however, from magnetite to hematite and siderite, and again from hematite to siderite, as conceived and symbolically expressed by Mr. Spurr, are impossible reactions without intermediate reduction. The common transformations to be considered with relation to change of volume are namely, of combined ferrous oxide to hydrous ferrous carbonate and ferric hydrate, and of anhydrous ferrous carbonate to ferric hydrate and anhydrous ferric and magnetic oxides. Spurr, *op. cit.* 162.

‡Am. Jour. Sci., XXVIII, 416; Trans. Amer. Geol., Min., Eng., XIII.

have since made known many striking exhibitions of the same types, especially in the iron-ore ranges of the lake Superior region. Among the ore-developments in pre-Cambrian terranes, and associated intrusives of that region the prevailing modes of occurrence conform to these types. Both kinds of replacement are sometimes represented in individual parts of connected and related ore deposits, the dominance of one or the other in a given locality being governed by relative distribution of associated sedimentary and intrusive rocks, or by radical differences in origin—whether from essentially calcareous or pyroxenic material. After much elaborate study and protracted discussion of the mode of origin of the Huronian (Algonkian or pre-Keweenawan) iron-bearing formations of the lake Superior region, both folded and structureless, their derivation as a rule by epigenesis *in situ* without sedimentation, remains questioned by few among later investigators.*

Recurring to my previous notice of the so-called Mediterranean iron ores of Spain and Algiers,† among products of replacement on a large scale upon the evidence of certain descriptions of their modes of occurrence, I take occasion to remark that they are likewise so regarded by recent observers like Mr. Fred. Kensington and Mr. A. P. Wilson, abstracts of whose original papers have been printed in a report by the U. S. Geological Survey.‡

An interesting field for observation of the same class of phenomena is presented on certain islands of British Columbia, visited by the writer in the summer of 1894, namely, Vancouver, Texada, and Redonda.

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§Ann. Rep. Geol. Surv. of Canada, 1873-74; 1876-77; 1886. Part B, p. 32.

Plate II.

Fig. 1

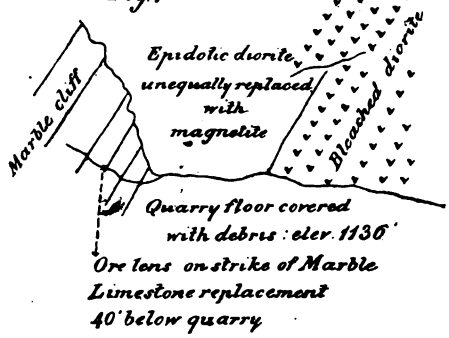


Fig. 2

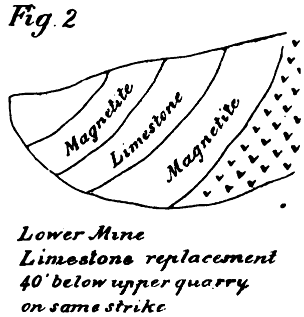
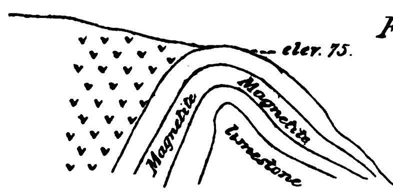


Fig. 3



Logan Location. Serita R Barclay Sound
Vancouver Island

In replacement of pyroxenic and lime-feldspar rocks of the greenstone family, like diorite, diabase, gabbro, etc., and other basic rocks, whether metamorphic or intrusive, residual concentration or fixation of stable iron oxides is brought about through initial decomposition of ferrous and ferric silicates, chiefly the former, whence development of soluble alkaline carbonates along with ferrous salts, whence again spontaneous double decomposition, and finally isolation of insoluble residues. This cyclus or process of weathering action is obviously regenerative.

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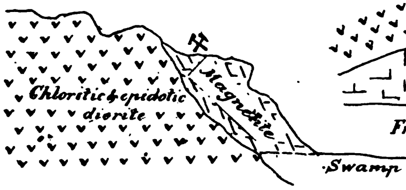
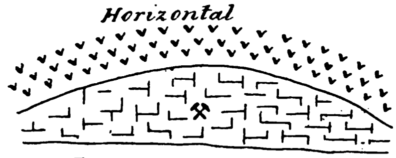
Plate I.

Vertical *Fig. 1*



Horizontal

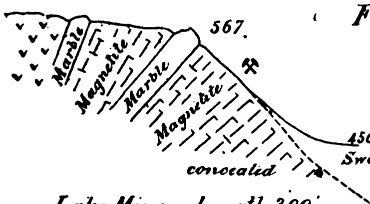


Front surface of erosion, 272' long

468'

Fig. 2

Paxton Mine. Texada Island



Lake Mine - Length 300'-

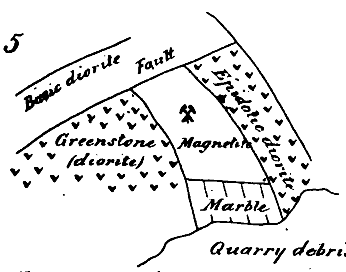
Texada Island

Fig. 3

Fig. 4

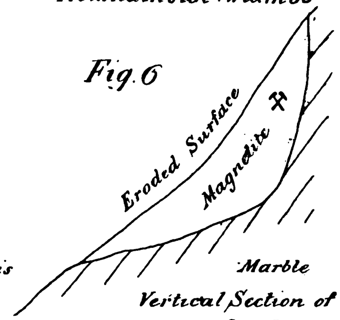
Terminal presentation on Mountain side: width 36'

Fig. 5



Exposure in Cliff
West Mine - Redonda Island
Terminal presentation on Quarry face

Fig. 6



Vertical Section of upper Ore Lens

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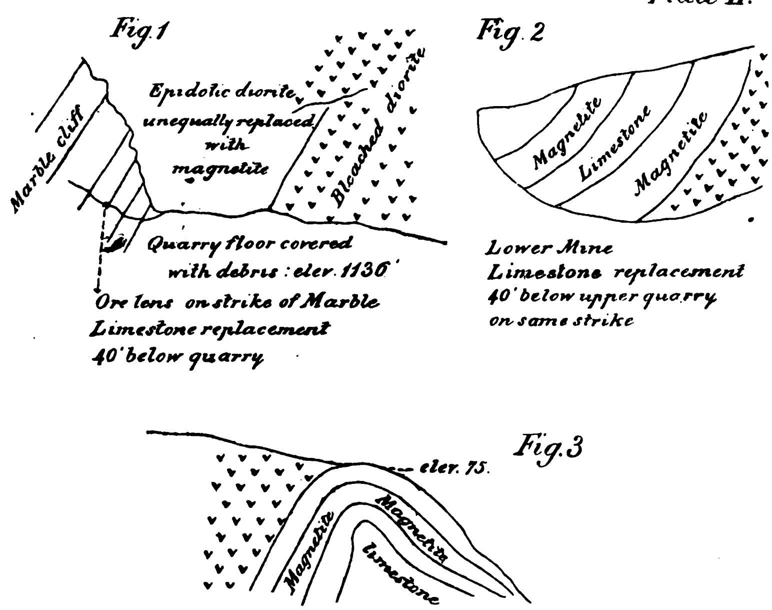
Plate II.



Logan Location - Serita R Barclay Sound
Vancouver Island

traversed by a belt of later syenite. Crossing the island, this spreads out in a crescent between the south and north shores. Between the syenitic mass and the Vancouver series stretches a narrow belt of metamorphic limestone forming in places the disrupted base of the series. The Vancouver member adjacent to the marble is apparently the weathered product of a basic aggregate—graduating into diabase and diorite all excessively epidotic from alteration of pyroxene and amphibole. This material is designated by the Canadian geologists as diorite, a generic identification, which will be adopted in the present paper for want of specific microscopic determination. This is more or less stratiform and differentiated in color according to degree of alteration. Epidote is the most conspicuous constituent, especially in close relation with developments of magnetic iron ore.

The intercalation of metamorphic limestone with eruptives, as remarked by Dr. Dawson, indicates the close relationship in time of the two classes of rock, which even apart from the facts afforded by similar association elsewhere, renders it necessary for the present to regard the whole as forming one great series, otherwise largely made up, it is believed, of highly metamorphosed sediments which have passed through a semi-fusion. The limestone however seems to occupy the relation to the Vancouver series of a basal formation overflowed by successive emissions of eruptive material by which it is sometimes interpenetrated, lifted and disrupted. The syenite bears evidence of subsequent upheaval, referred in point of time to a period later than the Cretaceous when strata assigned to the coal-bearing series of the Comox basin were deposited near Gillies bay.

Occurrences of magnetic iron ore of each kind of epigenesis which I have observed on the islands of British Columbia, as above instanced, are singularly uniform in character and in topographic as well as in petrographic environment. Apart from magnitude and conditions of erosion differences between them are mainly in their relations to a uniformly rugged surface; that is, as to their development on the flank or on the end of a slope. On the flank or near the surface of a slope, like three out of four of the separate ore bodies discovered on the south side of Texada, such occurrences are commonly well

defined, and their practical importance easy to estimate. When, on the other hand, the ore development is a terminal one, disclosed only upon the edge, and enclosed between eruptive material and disrupted masses of limestone tilted at high angles, little indication is afforded of the shape and size of ore bodies. Such an attitude is generally in a bold escarpment sometimes inaccessible above the immediate base. One of the ore bodies of this description on Texada, is exceptionally well exhibited—in part by excavation. These remarks also apply to developments of ore in connection with terminal outcrops of limestone in a dioritic environment on the north side of Redonda island, and again to similar ones on the slope of Broughton peak, at the head of Barclay sound. A remarkable occurrence of an ore body near the mouth of the Serita river, at the head of another bay of the same inlet, affords a fine example of partial but still extensive replacement of limestone, around nuclei or cores of that material, as distinctly seen both at the end and on the slope of the elevation near the surface of which the alteration has taken place. Some of these occurrences will now be described.

Texada Island, Strait of Georgia. The old operations of the Puget Sound Iron Company of San Francisco afford satisfactory exposures of the separate conditions under which magnetic iron-ore of both modes of epigenesis occurs. Quarry workings extend at intervals from the south side of the island about three miles, northwest from Gillies bay, following a single slope rounding a lofty summit of syenite at a general elevation of about 450 feet. On the range of the ore belt however the slope is more or less broken into hills by erosion.

Ore bodies within compass of the limestone belt are approximately lenticular in shape. All have been exposed to subaerial erosion, only so much of each development having been preserved as fell behind the eroded surface of the mountain side. In the several workings cores of marble are visible, corresponding to unaltered interior or nether parts of ore bodies, left standing after excavation of the ore.

Within compass of the epidotic rock the development of magnetite has been less regular, and less in concrete form, and the replacement or alteration less complete, the epigene product being a mixture of magnetite and epidotic material

sharply differentiated. This product may be more particularly described as a reticulation of the epidotic mass with compact magnetite, one distinctive property of which is its ringing sound when struck with a hammer, a property common to similar products of alteration of dioritic dykes associated with the ferriferous replacements of coralline limestone in Cuba.

Another physical property of the siliceous replacements or epigenic concentrations in eruptive material in common with all others which I have observed is a marked prismatic cleavage, which also serves to distinguish them from derivatives of limestone, mineralogically identical, but the tendency of which to pronounced cleavage does not extend as a rule to minute subdivisional fractures. A third common characteristic in eruptive (epidotic and dioritic) paragenesis is the amorphous constitution of the ferriferous product except when in the form of distinct lenses as at Cheery creek, Kamloops lake, British Columbia. Distinguishing criteria, thus noted, are observed not only in all occurrences of the kind on the islands of British Columbia, but also in such as I have visited in the Cascade mountains—namely on Money creek, at Snoqualmie pass (Denny claims), and again on the Cle-Elum river, as well as in the Santiago district of Cuba.

Both types of ore bodies are seen in juxtaposition at the Prescott mine on Texada—the replacement of marble as far as it is developed being complete, and, as usual without transition or incipient stages. The product is densely subcrystalline, and of remarkable compactness and richness. The conversion however is only partial, the front portion of a detached mass of limestone only having been replaced with magnetite together with its two ends, the back portion adhering to the cliff, and the whole mass of ore passing with characteristic changes of physical qualities and of material into compass of the diorite. The alteration of the diorite appears to have been through an epidotic transition, the locus having been determined by planes of jointing. Further internal development of ore has followed planes of cleavage. Hence a reticulated mass of epidote varying extremely in its admixture with ore. Taking the two kinds of product as forming a single ore-body, it may be succinctly described as a partial replacement of a detached

and disrupted mass of marble involved in eruptive diorite, side by side with an alteration of overlying eruptive directly in contact with the original calcareous mass. The altered eruptive merges at both ends of the ferriferous portion insensibly into unaltered and non-epidotic diorite. Regarded as a single ore-body its maximum thickness was about 30 feet by about 100 feet in length and 40 feet in hight. It has practically been worked out. But little material except of indifferent quality, from excess of epidote, remains unbroken or amongst the refuse of the quarry. Shipments of 3,000 tons of ore from Texada to the works of the Puget Sound Iron Co. at Irondale, Washington, during a period of four years ending in 1888 were mainly from this quarry.

This occurrence is thus described in detail because its character is well exhibited by excavation. In conclusion, it may be remarked further that upon the steep flank of the syenite summit in front of the disrupted limestone belt, the connected ore-body lies in a lap of diorite in a position favorable to weathering action, but directly exposed to superficial erosion from which it has greatly suffered, as attested by an abundance of heavy float strewn over the slope below.

Development of ore by both modes of epigenesis is clearly attributable to the environment of a mass of limestone with basic eruptive, and to topographical conditions favorable for weathering action—of the nature of chemical permutations in place between soluble ferrous sulphates and alkaline carbonates developed by oxidation. Alteration in the diorite resulting in residual concentration of magnetic oxide seems to have taken place through primary development of ferric hydrate from epidote, this ferric silicate being as usual a secondary product from weathering of amphibole and pyroxene. Within compass of the limestone, ferric hydrate, passing into ferric oxide and thence into magnetite, has likewise been developed from hydrous ferrous carbonate, probably spontaneously, by double decomposition between ferrous salts and calcic carbonate—ending in complete and stable ferriferous replacement of limestone.

The Paxton ore body is a replacement of limestone, apparently complete, at the base of the same slope about one mile inland, rising to a hight of about 70 feet above the level of a

swamp by which the nether portion is concealed, and the elevation of which is about 468 feet. (Plate II, figs. 1-2.) The longitudinal axis of this lens is about 250 feet, and the thickness of its upper face about 30 feet. Probably less than half of the original lens has been preserved from erosion. It lies in a lap of epidotic diorite, the replaced limestone having been entirely surrounded by eruptive material, contiguous portions of which, as in the Prescott mine, have undergone alteration. Partially altered material of the same description is seen on top of the ore ledge, and cupreous stains occur in spots. Horizontal as well as vertical sections of this ore lens are distinctly crescent-shaped. It stands unbroken as first discovered. No nucleus of limestone is disclosed. The ore product on exposed faces is crystalline and partially disintegrated.

About one mile still further inland and similarly situated at the base of the syenite summit bearing on its flank the fragmentary limestone belt, is situated the Lake mine, so-called, also an unwrought ore body. (Plate II, fig. 3.) It illustrates both kinds of replacement, derivations from limestone apparently predominating. Two belts of limestone are visible in cross section at the northern end—one occupying the middle of the ore-body, and the other forming its inner cover, their dip being a retreating one into the hill of which the formation is principally diorite. The lower limit of the ore development appears above the level of the swamp about one third way up the slope, and the top of the ore-ledge as spared by erosion 117 feet above the same level. The hight of the ore-mass as preserved is accordingly about 78 feet—its length about 200 feet, and its maximum thickness about 50 feet.

The Texada mine nearest the Texada landing was the working first opened on the island, but was soon abandoned on account of its pyritous character. The ore-body is well exposed at the N. W. end of the limestone belt. It consists of a block of ore of which the vertical face is about 40 feet high and 10 feet wide, between walls of limestone and diorite. The extent of this replacement beyond the elevated outcropping end of the limestone belt has not been traced, it having been uncovered only at its terminal presentation in a natural bluff. Occasional indications of ore along the upward and inland strike of the belt observed by Mr. Richardson, suggest

more or less continuity of the ore development, or at least occasional replacements of disrupted masses of limestone on the flank of the syenite summit for a few hundred feet from the old working.* Search in this direction was not resumed. But the admixture of pyrite in the ore exposed in that working is in deleterious proportion. Heavy float overspreads the surface below the ore bluff, and outcrops of ore, apparently in place, on the same slope below, point to a probable occurrence of other ore bodies at lower elevations on the same strike. A similar tendency to recurrence of ore developments at different elevations on terminal edges of disrupted limestone belts on Redonda island, and on Broughton peak, Barclay sound, was likewise suspected. In neither instance however have excavations been made to uncover concealed ore lenses, if such they be, on the strike of the terminal ore bodies exposed at these several localities, all discoveries of the kind having been in natural exposures on the face of cliffs, bared by erosion and at considerable elevations. Ore bodies, like the three on Texada first described, whose longer axes are with the crest of elevations on the sides of which they are lapped, are, on the contrary, all developed toward the base of moderate elevations an apparant rule to which the ore body of the same type on the Serita, Barclay sound, proves no exception. In such circumstances there is of course no scope for recurrence of ore in a given cross section except under cover of a low talus or mantle of drift, as on Texada, below the level of the swamp. That any development of ore occurs below water level—there seems no reason to conclude.

Besides the occurrences above noticed, other small indications of magnetite along the extension of the limestone belt have been observed by previous visitors,† notably one occurrence on the northeast side of the island. At the point referred to, crystalline limestone, according to Dr. G. M. Dawson, occurs in association with hard greenish altered volcanic rock of the usual character.

"It is in some places quite free from magnetite, but is generally highly charged with that material, which, though forming in it in very irregular masses of hard ore, has generally more or less of a stratiform

*Geol. and Nat. Hist. Survey of Canada, 1896, part B. p. 36.
†*Ibid.*, p, 39.

arrangement, and is occasionally found minutely laminated with calcareous matter. The most important solid stratiform mass of magnetite seen is about four feet in thickness. Epidote, and in some places small quantities of quartz, occur in association with the ore, which when the limestone is removed by weathering, generally forms black masses of pure (vesicular) magnetite." The beach is strewn with loose blocks (of ore) derived by this process of weathering from the limestone. "The contact of the limestones and volcanic rocks with the granite is close by to the south on the shore."

The above observations of Dr. Dawson are thoroughly in accord with my own on the opposite side of the island, and perfectly consistent with the present explanation of such deposits by replacement of limestone.

West Redonda Island. The Redonda islands, two in number, are high and mountainous, culminating in lofty peaks from 3,000 to upwards of 5,000 feet in hight. Cut out of the general outline of the coast by fiords, they obviously represent insular or partially submerged projections of the Coast range of British Columbia. Touching at one point only of West Redonda, namely at the De Wolfe iron mine on the north shore, Pryce channel, I found the formation to be identical with the Vancouver complex, no granite or syenite coming under my observation, though the former is stated by Dawson to be exclusively the formation of the island. The occurrence of magnetite was also observed to be under similar conditions and in similar environment to circumstances distinguishing occurrences of the same secondary product on the islands of Vancouver and Texada.

The De Wolfe mines are at an elevation of about 600 feet on a steep slope rising abruptly from the water's edge and at an angle of some 60 degrees. During the year 1893, magnetic iron ore, 626 tons in all, was shipped to the Oswego Iron and Steel Co's furnace in Oregon from two quarry-like workings, about 200 feet apart, in irregular masses of ore developed on separate belts of crystalline limestone, the terminal edges of which under a high dip to the west, are traced up the mountain slope as far as passable.

The West Mine so called (Plate II, fig. 5–6) may be described as the altered outcrop of one division of the limestone, interposed between courses of greenstone or epidotic diorite, and cut off at the top by a faulted mass of less altered and highly basic

diorite. The floor of the quarry is in marble—a sharp demarcation here taking place between the development of ore and the parent marble. The ore mass together with a bleached overlying greenstone forms half an arch over a boss-like mass of diorite —the crown of the arch being obliquely cut by the superincumbent mass of basic diorite along a distinct plane of fracture and dislocation. Viewed in section coincident with the strike of the limestone, this ore-body may be considered as presenting the edge of a lenticular replacement of limestone, shelved or lapped in unaltered material, and of very circumscribed extent. The upper portion only remains unwrought. The dip of the series brings in above the limestone a cover of diorite toward the verge of the quarry shelf. On the edge of the replacement proper—the dioritic greenstone has been altered into an epidotic magnetite by residual concentration of this product. The front of the ore-body has suffered from erosion which served however to disclose its upper part to view in an almost perpendicular cliff, whence the mountain rises very abruptly, thus forbidding further ready exploration along the culmination of the same belt.

The East mine, some 60 feet higher, presents the simple structure of an eroded boss of magnetite arching over an interior mass of marble, the connected boss being cut off at the base by epidotic diorite, and the whole structure truncated in front by erosion, and so exhibited in the scarp of an almost perpendicular cliff on the precipitous face of the mountain. The structure referred to may be likened to an egg obliquely divided. (Plate II, fig. 4.)

Outcrops of ore in association with marble are observed below, but have not been prospected. The conditions above remain undetermined for want of exploration. Both occurrences, as above described are developments of ore within and around disrupted masses of limestone involved in basic eruptive material, though appertaining to a distinct belt which has been subjected to violent disturbance and upheaval.

The occurrence of such ore bodies on West Redonda island is not without significance as bearing upon the possibility of similar occurrences on the steep shores of navigable inlets heading in the unexplored border of the Coast range.

Vancouver Island, Barclay Sound.—Discoveries of magnetic

iron ore at the head of Barclay sound are at an elevation of about 1136 feet on the slope of Broughton peak facing the sound. The developments, as usual, are in connection with metamorphic limestone which overlies them, but they seem to be in part within compass of a belt of bleached and highly altered greenstone—somewhat epidotic in places, interposed between the limestone and an underlying belt of quartzite more or less epidotic (Plate II, fig. 1). The development of ore is very irregular and far from continuous. The belt within which it is found is gullied by erosion. Parts of the lower bands of the limestone have given away to replacement of magnetite, portions of which have subsequently been eroded. A few blasts only have been put in, but enough to disclose the fact that about one-half of the ore development in sight is within compass of the limestone, and the other division within compass of the underlying quartzite or bleached diorite. At the lowest level exposed by blasting one irregular mass of ore nearest the underlying quartzite measures about eleven feet across. The whole occurrence conforms to what has above been distinguished as a terminal presentation of an outcropping edge of a limestone belt locally replaced with magnetite. For lack of solidity this replacement can hardly be described either as a concrete ore-body or as a lens, the replacement probably being superficial. Two kinds of replacement are here exhibited as usual, distinguished in the manner above indicated.

Some forty feet lower, on the flank of the mountain, a lens of magnetite twelve feet thick on the face, developed around a nucleus of unaltered marble, is exposed on the strike of the same belt in a lap or shelf of that material. This is of the nature of a replacement of limestone. (Plate III, fig. 2.) Overhanging cliffs of limestone tower above the higher exposure. Further than as thus described no indications of ore bodies on the upward strike of the limestone belt seem to have been made out by the explorers whom I found encamped upon the mountain. What has been exhibited on Broughton peak is therefore scarcely of economic importance.

Serita (Logan Claim.) On the Indian reservation, near the mouth of the Serita river, and about one mile from its east bank, a remarkable body of magnetite has been discovered on the face of a low hill. This development is of the same type

as the Paxton and Lake lenses on Texada. It rises to a hight of 75 feet above tide, its base near water level being concealed. (Plate III, Fig. 3). Longitudinally its outline in section is that of a crescent. At the east end of the bluff-like elevation it is exposed in cross section, and its structure fully revealed as a replacement of marble of which the axial portion remains unaltered. On both sides of this midrib of unaltered marble ore is developed to a maximum thickness of about 30 feet, with reverse dips of 84° to 85°, resulting in an anticlinal configuration. The length of the ore-body may be taken as about

200 feet. Prismatic blocks of magnetite were found developed around angular masses or cores of marble. These are here represented by photogravures. No other discoveries have been made along the extension of the same marble belt. The environment of this belt is eruptive rock of the usual dioritic type, more or less epidotic according to degree of secondary alteration.

Sooke Harbor. On the second headland facing the Strait of Fuca south of Sooke harbor, a differentiation of magnetite from weathering action on exposed surfaces of a basaltic diorite has led to the enumeration of this locality among the known occurrences of iron ore on the island of Vancouver.* A number of shallow excavations, while affording some material of excellent quality, suffice to show the superficial character of this development upon glacial surfaces of a considerable area bordering the precipitous shore of the strait. A correct notion of the character and limitations of this occurrence may be formed from its description as an incipient and

*Min. Wealth of British Columbia. Geol. and Nat. Hist. Survey of Canada. An. Rep., 1887, Part R, p. 100.

strictly superficial secondary differentiation of magnetite, from extremely basic primary magmatic differentiations,nearly vertical in attitude, clearly defined within compass of the superficial expanse of the basaltic eruptive.

The following analyses of magnetite from the several localities above referred to fairly represent the secondary products as described:

	I	*II*	*III*	*IV*
Ferric oxide........	....	....	67.31	....
Ferrous oxide........	....	....	28.33	....
Magnetic oxide......	91.13	91.94	....	....
Silica....	1.79	4.10	3.97	4.353
Alumina	0.14	0.65	....	0.220
Lime..............	$CaO\ CO_2$ 0.96	2.01	....	2.234
Magnesia.........	$MgO\ CO_2$ 2.08	1.03	....	1.300
Manganese	Mn_2O_3 0.64	0.21	....	MnO 0.110
Sulphur.............	0.06	....	0.036	0.015
Phosphorus..........	0.003	0.0264	0.030	....
Potash	....	....	....	0.080
Soda	....	....	....	0.230
Moisture	....	....	....	0.045
Iron................	66.32	66.58	69.00	65.896

I. Broughton peak, Barclay sound, Otto Wuth.
II. Money creek, Washington. Otto Wuth.
III. Texada island, E. I. Chapman.
IV. Redonda island, F. G. Wait.

THE EASTERN LOBE OF THE ICE-SHEET.

By C. H. Hitchcock, LL. D., Hanover, N. H.

In August, 1896, I visited the Adirondacks for the purpose of learning the direction and extent of the ice movement. Geologists have rarely placed any observations of this kind upon record. Vanuxem states that the Adirondacks constituted a center from which the glaciers moved outwards in every direction; but presents no facts in support of this view. Professor Chamberlin presumes from all the data in his possession (1883) that massive currents swept around these mountains both from the Champlain and St. Lawrence valleys, "while a further current, at the hight of glaciation, probably passed over the Adirondacks, and gave to the whole a south-

erly trend." I have been unable to find in geological literature any notice of actual observations upon the striæ or till of this region. Hence I fulfilled a long cherished desire in studying the glacial phenomenon about Mt. Whiteface, one of the best known and most conspicuous mountains in northern New York.

In passing through Jay and Wilmington striæ were observed pointing S. 50° W., and the till contains boulders of Potsdam sandstone besides various granites. Mt. Whiteface exceeds 4000 feet in altitude, and rises considerably above the general level of the adjacent elevated country. Nearly the whole of the mountain is covered by till, made up principally of anorthosites and fragments of Potsdam sandstone. I was unable to examine the upper three hundred feet of the peak, but have no reason to suppose the facts are any different there from what have been mentioned; but it was quite a disappointment to me, not to have been able to search for striæ or glacial smoothing at the very summit. Prof. H. P. Cushing and Mr. F. B. Taylor tell me in conversation that a corresponding S. W. direction is the prevailing one all over the north flank of the Adirondacks. Following up Lake Champlain the course is usually southerly, but the S. W. direction commences very near the water, as at Crown Point. Professor Kemp reports a S. W. course as prevalent about Moriah. Vanuxem mentions the occurrence of the peculiar granitic boulders of the Adirondacks in the counties lying to the southwest, as in Herkimer, Montgomery, Oneida, Otsego, Madison, Cortland and Tioga.

The conclusion naturally following from these statements is that the Adirondack region has been swept over by the ice from base to summit. The hard sandstones everywhere contribute extensively to the composition of the till, and indicate by their presence as well as by striæ and the dispersal of the granite blocks, the direction of the movement from the northeast. Probably every square mile of this elevated region has been covered.

This conclusion was not anticipated, and hence gives us a different and consequently a better idea of the real movement of the ice sheet east of western New York. As is well known the direction of the ice over New England, including all the

high Green and White mountain summits, was to the southeast. Between New England and the Adirondacks in the Champlain valley there is a narrow area where a southerly direction prevailed. The line of no divergence follows down the Hudson to about the New Jersey boundary and then terminates west of the Palisades. In the Catskill region and in Pennsylvania the course is to the southwest, and in all the maps the striæ are made to point at right angles to the great terminal moraine from near Easton, Penn., to Salamanca, N. Y.

If these divergent courses are to be interpreted like those in the morainic loops further west, as in those connected with lakes Erie, Michigan, and Superior, it means that a lobe of the ice sheet of enormous thickness started from the Laurentian highlands and pushed southerly, naturally following the depression of the Champlain-Hudson valley. Enough ice was moved to override the highest New England and New York mountains, while it does not seem to have been urged so far to the south as that which pushed down the Mississippi valley.

Several general and special peculiarities of the ice-movement east of the great lakes are better understood in the light of this generalization.

1. In a general way we can speak of a *New York and New England* lobe of the ice sheet which may or may not have been co-eval with those connected with the basins of the great lakes. This particular ice current did not extend to the west beyond the angle in the moraine near Salamanca, and cape Cod represents the eastern limit of what can be observed above the ocean level.

2. There are evidences of morainic material beneath the sea as far as to the termination of the submerged Hudson river channel—about eighty miles beyond New York. The great bar at the end of the fiord is shaped like a moraine or material derived from it. Lindenkohl notes the coincidence in direction of the submerged channel with the New Jersey moraine as far as to the bar, which may have been the extreme end of the lobe and thence the edge may be traced northeasterly to Martha's Vineyard. Dr. A. M. Edwards has shown by an examination of the soundings that the material in this triangular area out-

side of Long Island has probably been derived from the Palisade range of trap. Like that of eastern New Jersey it may be the relic of the more ancient attenuated border of the till.

3. Further knowledge shows us the limits of the inner Long Island moraine, suggested by Chamberlin to be the probable equivalent of the Wisconsin series. This starts at cape Cod, follows the Elizabeth islands, appears in Rhode Island, forms Fisher's and Plum islands, touches Long Island at Orient point, and borders the north shore as far as Port Jefferson, where it has been lost sight of. An inspection of the map, coast survey and others, shows a line of shallows called the "Stratford shoals" and the "Middle ground lightboat," which may connect Mt. Misery at Port Jefferson with Stratford point on the Connecticut shore. Is not this line the continuation of the inner terminal moraine?

Correlated with this morainic line may be the westerly direction of the striæ over the Connecticut valley. Dana has noted them as far south as Milford—S. 34 degrees W. and elsewhere to the north within the state. In Massachusetts my father has described them with a trend west of south, and I have followed them up to the White mountains in New Hampshire and Vermont. The most remarkable ones are at Granville, Mass., 1240 feet, in the neighborhood of Shelburn Falls, Mass., and Halifax, Vt.; both upon land exceeding 1800 feet in altitude. These represent more than the usual low-lying striæ of the local Connecticut glacier. Following the statements given above of the divergent courses in the Hudson valley, we have similar facts repeated in the Connecticut, with the corresponding divergence to the southeast on the eastern rim of the valley. The Connecticut lobe, therefore, is shorter than that of the Hudson and seems to be terminated by the inner Long Island moraine.

4. There are quite a number of morainal lines in New England, comparable in number with those observed in the West. Beginning outwardly there are: (1) The attenuated border southerly from Staten island. (2) The Long Island moraine from Martha's Vineyard, Block island, and the whole length of Long island, Staten island, New Jersey, and so on to Salamanca, N. Y. (3) The Connecticut moraine from cape Cod and the north shores of Long island, crossing the sound to

Connecticut, and thence northerly. (4) The Queen's river moraine in Rhode Island, as reported by Mr. Woodworth. (5) Prof. R. S. Tarr describes a moraine extending from cape Ann, Mass., westerly to near Connecticut river. (6) A possible line may be indicated by moraines in Wakefield and Cottonborough, N. H., to connect with the damming up of the Alton bay end of lake Winnepiseogee, large ponds in Gilmanton, Northwood, and Barnstead, and the enormous sand-plains near Concord in the Merrimack valley. (7) Another line in some localities characteristically developed from Conway through Albany, Tamworth, Sandwich, south border of Squam lake, Newfound lake, moraines south of mount Cardigain, etc. (8) Another line may be indicated in the morainic piles south of Gorham, Carroll, Whitefield, and Littleton. This may connect with similar deposits in Rygate, Corinth to Randolph, Vermont. (9) Perhaps the most important line has been located at Willoughby lake, Vt., thence southwesterly to Woodbury. This lies on the watershed between part of the Connecticut hydrographic basin and the streams flowing into lake Champlain. In an early publication I imagined a line of moraines from the Androscoggin lakes in Maine across by the way of Willoughby lake westerly to a supposed accumulation between the Lamoille and Winooski rivers at lake Champlain. Since then it has become apparent that more than one moraine must be indicated by these mounds, since their course should be northeast and southwest, or at right angles to the ice movement. Doubtless these particular lines may not all be verified, but their number cannot very well be less than has been indicated. There must also have been other moraines farther north, and I think I have seen traces of one at the south end of Memphremagog lake in Newport, Vt.

5. Very likely the distribution of the drumlins may be somewhat connected with morainal lines. If found near the margin of the ice sheet they should be distributed behind certain prominent moraines. These hills seem to be bunched very extensively in Massachusetts and southern New Hampshire, or between lines (4) and (6), and they are very rarely met with outside of these limits except near lake Champlain. Those near Boston covered by broken shells of temperate mollusca teach an important lesson of succession. The drumlins seem

to have been accumulated in an ice age, when the mollusca could not have flourished in Massachusetts bay. After the incoming of a warm interglacial epoch a later incursion of ice ploughed up the sands with their contents and carried them with other material to constitute the drumlins, which probably rest upon an earlier ground moraine. The shells are not Tertiary, and as they abound in the drumlins which are unquestionably of glacial origin, clear evidence of at least two glacial epochs is afforded. These mollusca could not have flourished when the ice pushed into Massachusetts bay. They must have migrated along the New England coast in an interglacial epoch. Nor can they be correlated with the Champlain epoch because that fauna had a glacial character.

The drumlins of western New York can be seen to be situated between morainic lines, and may be correlated in a general way with those in eastern New England. They belong to the Ontarian rather than the eastern lobe ofthe ice sheet.

6. The progress in glacial studies made by the Canadian Geological Survey, as represented by Mr. R. Chalmers in the last two annual reports, indicates a readiness to accept better views. There was first a glacial epoch when the ice moved northerly from the New England area, and the auriferous gravel's of the Eastern Townships were laid down. Secondly, there was an interval, interglacial, without the presence of ice. Third, the glaciers of the Laurentian area moved southerly across the St. Lawrence valley, and in at least one instance crossed the hight of land towards the Atlantic between the Chaudiere and St. Johns valleys. As this conclusion is derived from the presence of granitic boulders, brought from the north side of the St. Lawrence, the same must be the case wherever the boulders can be shown to have come from the same direction moving uphill. That will agree with our contention of the covering of all New England by the Laurentian ice sheet. Fourthly, the Champlain epoch with its beaches and fossils succeeded—a time of marine invasion. I have only added to these last admitted facts the query whether the Champlain epoch was not truly glacial, with icebergs moving both from the Laurentian and Novanglian mountains, and chilling the waters so much that only a boreal fauna could exist. It was this same fauna that flourished at the same epoch

on the coast of New England as far south as cape Ann, and after the accumulation of the drumlins carrying a temperate fauna. These epochs may be correlated also with the diverse successive faunas of Sankaty head in Nantucket.

THE SYSTEMATIC POSITION OF THE TRILOBITES.

By J. S. Kingsley, Tufts College;
With Remarks by C. E. Beecher.

Within the past three or four years our knowledge of the structure of the trilobites has been wonderfully increased, until now it would seem that we must have a pretty accurate and detailed acquaintance with the external anatomy of one or two forms. I have had no opportunity for studying any of these recent finds and must rely upon the published accounts of the researches of others for my knowledge of details. My only excuse for entering upon this field is that I have some acquaintance with the structure of recent arthropods and that the conclusions to which I am led are somewhat at variance with those which have been recently set forth.

That the trilobites are true crustaceans seems now placed beyond a doubt; but their position within the crustacean phylum is by no means as certain. Of the recent authors who have discussed this matter, Bernard ('95) claims that the trilobites are closely related to the Xiphosures, and again in the same paper, that they "are, in reality, pre-crustacean. They represent a stage more primitive than Apus, *i. e.* nearer to the original annelidan ancestor of the whole phylum."

Beecher, on the other hand ('95, '97), believes that the larvæ of the trilobites are closely related to the regular crustacean nauplius, and more nearly represent the primitive ancestral larval form of the crustacean than does the nauplius. Again ('95) speaking of the adults he says that they "are shown to be a primitive type in (1) their multiple segmentation, (2) the irregular number of their thoracic appendages, and (3) the biramous structure of their legs. They therefore present characters common to the Entomostraca and Malacostraca."

In reading Dr. Beecher's early papers one gets the impression, although this is not definitely stated, that he is inclined

to regard them as most nearly related to the modern phyllopods, although in his latest he is inclined to assign them the rank of a sub-class, equivalent to Entomostraca and Malacostraca. None of these suggestions, except the last, commends itself to me.

In the first place, as opposed to Bernard's view, all existing evidence goes to show that the trilobites are truly Crustacea; the Xiphosures are as clearly nothing of the sort. Not a single homology can be drawn with any degree of certainty between Limulus and any trilobite. The regional divisions are different; the appendages are built upon a different plan, while the larvæ of the two groups present but the slightest and most superficial resemblance to each other. Certainly, if Beecher's suggestion that the larval (Protaspis) stage of the trilobites represents the ancestor of the nauplius be correct, then the larvæ must be totally distinct, for Limulus shows nothing in its development in the least approximating a nauplius stage.

But is this Protaspis stage possessed of nauplius characteristics? Is it to be regarded as a "protonauplius"? I think not. The characteristics of the crustacean nauplius are a (usually) unsegmented body, bearing a single median ocellus and three pairs of appendages. Of these the first is pre-oral and unbranched, the other two are biramous, and have their basal joints modified for mastication. The mouth is on the under surface; in front of it is the large upper lip. The vent is terminal and dorsal in position. Certain of these features are characteristic, not only of the nauplius, but of all metameric invertebrates as well.

In the larvæ of the trilobites median and pleural regions are differentiated, a condition, so far as I am aware, not paralleled in any nauplius and certainly not to be regarded as "protonauplian." No traces of the median eye have been found in any trilobite larvæ, a matter of no little importance. The trilobite larvæ, on the other hand, frequently possess paired eyes, a condition unknown in any nauplius. The cephalic region of the trilobite larva is segmented; in no nauplius is this the case. Further we *know* as yet absolutely nothing of the appendages of the youngest trilobite larvæ, nor of the characteristics of the upper lip. Beecher has restored

these portions with some plausibility in his account ('95) of the Protaspis stage, but I cannot help thinking that he may be in error here since he seems in all of his papers to regard the biramous structure of the crustacean appendage as the primitive condition, a supposition negatived by the thorough researches of Lankester ('81) upon the crustacean foot, and the confirmation of this view which we owe to Packard ('83). It should also be remembered that the great majority of embryologists agree in refusing to the nauplius much phylogenetic significance, holding rather to the view that its characteristics are adaptive rather than phylogenetic.

Dr. Beecher also places much weight upon the existence of five segments in the head region of the trilobites, as evidenced not only by the annulations upon the dorsal surface but by the appendages on the ventral surface as well. These he seems to regard as tending to show that the head in these ancient forms agrees "with what is generally accepted as the primitive [head] structure in modern true Crustacea." But this at once leads into many difficulties. Setting aside the fact that there seems to be no general agreement as to what constitutes the "head" in modern Crustacea* we are at once met with the fact that either the antennæ or the antennulæ are apparently unrepresented in the trilobite head. This involves more than a dilemma, for it has several horns.

First, we may assume that in the trilobites, as in some phyllopods and isopods, one pair of antennæ has been so reduced that it is no longer recognizable in the fossils. But with this assumption the conception of the trilobite head at once changes; it is no longer composed of five but of six somites.† On the other hand if we assume that there has been no dropping out of appendages, and proceed upon the basis of exact serial homology, then there comes the difficulty that the second pair of antennæ

*What, for instance, shall we recognize as typical for the crustacean head? In the Tetradecapoda we have a "head" with six pairs of appendages. In the Decapoda we can differentiate two kinds of "head" according as we recognize the mouthparts as cephalic appendages (eight segments) or as we take the cervical suture as constituting the boundary between head and thorax, a line of division which would give a head of only two segments (cf. Ayers, '85). Again the Phyllopoda give a head of three to six segments, according as we draw the line.

†Of course nothing can be said of the true segments of the head as indicated by the neuromeres, etc., as can be done with the embryos of existing forms. (Cf. Bumpus, '91, McMurrich, '95.)

of the true Crustacea are equivalent to what in the trilobites is regarded as the mandible, and we are at once forced to divide the whole crustacean phylum into two classes, the one containing the trilobites, and the other those forms which are undoubtedly crustacean, a division which seems to me warranted by many other facts of structure and which I have already adopted ('94) and which Dr. Beecher is also inclined to accept ('97, pp. 93, 94).

There is even less evidence to support the supposed phyllopodan affinities of the trilobites. The typical phyllopodan appendage has already been well described by both Lankester and Packard,* and there is nothing biramous about it, while there is much plausibility and even probability in the view that it represents the ancestral crustacean appendage, and is itself a direct derivative of the annelid parapodium. In the trilobites, on the other hand, the appendages, as shown (antennæ excepted) in the restorations of both Walcott and Beecher, are as truly schizopodal as those of any Mysis, and they exhibit in these restorations not the slightest approach to the phyllopodan type.

It is true that Beecher has already figured, side by side ('94, pl. VII, figs. 3 and 4) the appendages of trilobites and a larval Apus, the intention being to illustrate the similarity of form. It however seems to me that this comparison is untenable since it assumes that the endites of the phyllopod appendage are comparable to the separate articles of the so-called typical crustacean limb, a view which Lankester sixteen years ago showed to be without a true morphological basis.

In the trilobites the pygidial region (why not abdomen?) bears appendages serially similar to those of the thorax; in the phyllopods, on the other hand, this region in both young and adult is without limbs, aside from the caudal furca. In the trilobite the body is divisible into axial and pleural regions, and the persistence of this characteristic in all the genera with which I am acquainted gives it a greater importance than might otherwise be attributed to it. In the phyllopods, on the other hand, nothing of the kind is found; the carapax of the Apodidæ and the bivalve shell of the estherians being

*In the few points where Lankester and Packard disagree, I accept the interpretations of the former.

structures of a totally different kind. The little evidence we possess regarding the structure of the eyes of trilobites (Packard, '80; Clarke, '88) goes to show that their structure is greatly different from that of the eyes of the phyllopods (Claus, '86); and in no crustacean, as far as I am aware, is there any migration of the visual area such as is pointed out by both Bernard and Beecher as occurring in the group of trilobites.

On the other hand the resemblances between the trilobites and the isopods are of even more superficial character than those between the forms under discussion and the phyllopods. Body regions, appendages, everything, are dissimilar in actual structure; the resemblances are those of analogy, not even of convergent evolution.

Since Matthews's first announcement of the presence of antennæ in the trilobites, it has seemed to me that these forms must be regarded as constituting a distinct class of the Crustacea, and one considerably removed from the primitive stock, which I hold to be most nearly related to Apus* of all living forms. This group of Trilobitæ, according to my standpoint, left the other Crustacea before the introduction of the nauplius into the life history and before the complete differentiation of locomotor and masticatory appendages. The pentasomitic head is a feature peculiar to this group, as is also the variability of the thoracic region and the great development of the pleura.

I am sorry that the necessities of this discussion have required me so often to quote professor Beecher, only to differ from him. His work in elucidating the structure of the trilobites has placed the whole scientific world in debt to him; and I have no doubt that in all discussions which will follow regarding the relationships of the forms in question he will have the prominence which has been given to Burmeister and Barrande in the past. The differences between us are largely those of interpretation, and I present my views only for the purpose of drawing attention to the points involved.

Tufts College, Mass., March 14, 1897.

*This must not be regarded as implying any sympathy with the peculiar phylogenetic speculations of Bernard.

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Other references will be found in Beecher (1897) and in Kingsley (1894). Only those directly quoted are given above.

REMARKS BY C. E BEECHER.

As a preface to these remarks, it may be stated that there is no intention on the part of either writer of indulging in a controversy regarding trilobite affinities. Prof. Kingsley, as a biologist and authority on living arthropods, naturally approaches the subject from a standpoint nearly opposite to that of a trilobite investigator or paleontologist. The differences of opinion or interpretation held by each are generally more apparent than real, and, as stated, depend mainly upon the

point of view. Further it cannot be expected that students of Lang, Claus, and Lankester, will agree as to the value and significance of a number of important characters, or upon certain theories which have been the natural outcome of such differences.

In the study of trilobite morphology and classification, I have made homologies and correlations from theories, opinions, and observations, which seemed most current and in general favor in standard text-books. The chief purpose of the investigation was to work out the structure and development of the trilobite and to apply the information to a classification of the members of the group itself. The results have been recently published in the *Amer. Jour. Sci.* (Feb'y and March, 1897). No attempt was made to revise the classification of the animal kingdom from the trilobite standpoint, nor even to determine the branches of arthropod phylogeny. The discussion of the systematic position of *Limulus* was carefully avoided, though this is usually considered the chief end of any trilobite theorizing. The affinities of the trilobites were manifestly closer to the Entomostraca and Malacostraca than to other arthropods, and therefore comparisons were drawn with these subclasses of the Crustacea.

In the following remarks, only the main points of difference between the views held by Prof. Kingsley and myself are dwelt upon.

If the trilobites are true crustaceans, as conceded, it is then fair to expect a more or less close agreement between the larval forms of both. In my paper on "The Larval Stages of Trilobites" (AMERICAN GEOLOGIST, Sept., 1895) I endeavored to show this close agreement, and concluded that the protaspis stage of trilobites could be homologized with the nauplius larva of higher Crustacea. Prof. Kingsley notes the following differences: (1) the differentiated median and pleural regions; (2) the segmented cephalic region; (3) absence of median eye; and (4) paired eyes.

As to the first, I do not think the differentiation is much greater than in the nauplii of *Apus*, *Cyclops*, *Lucifer*, and others in which there are side regions. The pleural regions cannot be considered as highly specialized characters, since they are common to many groups, and each segment is considered as primarily consisting of tergum, pleura, and sternum.

(2) The segmentation of the protaspis is very feeble in the earliest stages, and is evidently emphasized from the fact that the fossils are viewed as opaque objects and exhibit strongly any inequalities of surface features, while living nauplii are studied as translucent objects. Furthermore, any such difference cannot be real, since the nauplius shows its true segmented nature in its paired appendages.

(3) The apparent absence of a median eye in the trilobite protaspis could be taken as of some value were it not that the fossils are not more than one millimetre in length, and even under the most favorable conditions could hardly be expected to show such small features as ocelli. Moreover, the median eye may have been marginal or ventral and therefore would not be seen in the fossil, which only preserves the dorsal crust.

(4) Paired eyes are not present, or at least not visible in the protaspis stages of primitive trilobites. They may through acceleration appear in the protaspis stages of later genera, as they do in the nauplius embryos of certain modern decapods.

I do not believe that the nauplius has any great phylogenetic significance, and have considered it "as a derived larva modified by adaptation" (*l. c.*, p. 190), and as a "modified crustacean larva" (*ibid.*, p. 191).

It does not seem necessary to correlate the post-oral second pair of trilobite appendages with the mandibles of higher Crustacea. The second pair in the nauplius is also post-oral and manducatory, though they later develop into the antennæ and are pre-oral.

As to the cephalon of a primitive crustacean, I have merely accepted the conclusion approved by Claus, as stated by Lang, in his reconstruction of the original crustacean, which is as follows: "The head segment was fused with the four subsequent trunk segments to form a cephalic region" (Comparative Anatomy, p. 406).

Similarly in regard to the interpretation of the biramous appendages, I have adopted the statements and conclusions of a large number of zoologists who consider the most primitive appendages as branched or consisting of a dorsal and a ventral member, and I have followed them in thus interpreting the trilobite appendages, which are clearly of this nature.

Yale University Museum,
New Haven, Conn., April 14, 1897.

SOME NEW FEATURES IN THE GEOLOGY OF NORTHEASTERN MINNESOTA.*

By N. H. WINCHELL, Minneapolis.

When the data that have been gathered during the last fifteen years relating to the geological structure of the northeastern part of the state came to be put together, in an effort to classify and map them for a final report, it was discovered, that there were certain vacua in the series of facts which we could not fill, and some points on which we had not enough information to warrant final report. It was for the purpose of supplying some of this lacking information that a small party was organized last September for the purpose of reviewing some of the rock outcrops which had already been examined. The results of this review are quite important and interesting. They are divisible into four parts, viz:

1. The nature of the transition from the crystalline schists to the Laurentian.

2. The nature and relations of the Stuntz conglomerate of Vermilion lake.

3. The nature and position of the coarse conglomerate in the Puckwunge valley, near Grand Portage.

4. The nature of the contact of the Saganaga granite on the Ogishke conglomerate at Saganaga lake.

I shall speak of the first three of these, and shall leave to Dr. Grant an explanation of the contact of the Saganaga granite on the adjacent conglomerate.

1. The nature of the transition from the crystalline schists to the Laurentian.

Under the term Laurentian have been included, in Minnesota, two different rocks, or formations, in the same manner as in many places in North America, viz., (1) an acid crystalline schist evincing definite and unmistakable evidence of direct derivation from a sedimentary rock without having suffered fusion, or displacement from the position it originally occupied with relation to adjoining strata, and (2) a rock which is massive, or simply leaved by some cause into sheets of a homogeneous character, the sheets themselves being merely separate layers of an apparently massive rock. The term

*Read at the December (1896) meeting of the Minnesota Academy of Natural Science.

Laurentian, if it have any chronologic significance, should be applied only to the former of these, and the latter, being of a later date as to origin and position, should have some other characterization. For the purposes of this discussion, they will be distinguished simply as sedimentary Laurentian, and irruptive Laurentian. The writer has already called attention to the differences that mark the crystalline rocks* whether igneous or sedimentary, and to the probable causes of those differences, based on theoretical considerations, and has reached the conclusion that the basal Laurentian gneisses, whether of the igneous Laurentian or of the sedimentary, must have had a cause other than that of normal irruption from the interior of the earth.† In an earlier paper read before the American Association for the Advancement of Science,‡ he also reached the conclusion, based on theoretical considerations, that "all acid eruptive rocks result from the hydro-thermal fusion of preexisting sedimentary strata embraced in the super-crust of the earth." At the same time this conclusion was based on field observations made in northeastern Minnesota. Since then Bayley has more carefully studied the rocks on Pigeon point and come to the conclusion that the acid rocks, at least of Pigeon point, have been derived from the fusion of the sedimentary strata concerned in the upheaval and metamorphism of the Animikie.§

I wish to call the attention of the Academy to certain field evidences that prove as certainly that the Laurentian igneous rocks are due to fusion of the crystalline schists, and further, that the same process which produced the crystalline schists from sedimentary strata, produced also, when carried to the end result, the igneous rock which, in the form of granite dikes and extensive bosses, invades and overwhelms them.

It is due to Mr. A. C. Lawson that geologists have become convinced that the igneous Laurentian is later than the sedimentary Laurentian, chronologically, although, in many in-

*The crystalline rocks: Some preliminary considerations as to their structures and origin. Twentieth Annual Report, Minnesota survey, p. 1.

†*Op. cit.* p. 27.

‡Some thoughts on eruptive rocks, with special reference to those of Minnesota: A. A. A. S., Cleveland, 1888, p. 212.

§The eruptive and sedimentary rocks of Pigeon point, and their contact phenomena, Bul. 109, U. S. Geol. Sur., 1893.

stances the igneous underlies the sedimentary, and from it the sedimentary strata dip in all directions. Mr. Lawson cites many instances in which the sedimentary strata are penetrated by the igneous, and in which blocks from the sedimentary have become separated from their parent masses and carried some distance in the mass of the igneous, remaining surrounded by the igneous after solidification, till the present, attesting their prior existence. He did not, however, attempt, so far as known, to assign an origin to the igneous Laurentian, except the general one of saying *it is an igneous rock.* When he saw numerous alternations of the sedimentary and the igneous, in parallel strata, however fine the sheets were, he explained such alternations by assuming that the sedimentary strata had been split numerously, along the lines of easiest separation, and that into the openings the igneous rock had been forced. Without attempting to enumerate at this time, the insuperable obstacles that present themselves to this idea, I will call your attention to the facts that have lately been noted with care on the northwestern shores of Vermilion lake. They seem to demonstrate two important facts in the genesis of the Laurentian, so plainly, that any competent geologist who examines the field relations will be convinced of their significance, and of the correctness of the conclusions drawn from them. These conclusions, already intimated, are as follows:

1. The sedimentary Laurentian is a crystalline condition of sedimentary strata which are conformably a portion of the crystalline schists.

2. The igneous Laurentian is the result of a more intense metamorphism, carried even to fusion of some strata.

The parties of the survey have passed many times through Vermilion lake. They have uniformly noted the marked sedimentary structure continuing from Tower northward, along the islands and shores, passing from the Keewatin to the crystalline schists without any interruption of the conformity of the strata. There is no break in the series. The crystalline character comes on gradually. The first important appearance of mica schist is on some of the small islands and on the coast which strikes across the southwestern part of T. 63–16, and into sections 35 and 36, of T. 63–17. This is at a distance of about three miles from the point where igneous granite

forms the country rock, and between these two points extends a narrow portion of Vermillion lake on the shores of which are frequent large exposures of the same schist, exhibiting beautifully the relation it bears to the igneous rocks that cut it. Suffice it to say here that the sedimentary character is perfectly evident everywhere, even to the very contact with the igneous granite, and this fact was specially noted, on the occasion of the last visit, by all the members of our party.* It may be of interest to mention, also, that two epochs or ages, of igneous intrusion upon the schists were noticed. This is true both for granitic dikes and for trap dikes; and the fact was noted at two or three miles from the granite boundary, and at several places.

Going northwestward from the commencement of the mica schist, one notices the increase in the crystalline character of the schist, and in the number and size of the granitic dikes. The critical point for observation is found, however, just as the transition occurs from schist to gneiss, and to granite. The point to which I wish to direct your attention especially is on the west side of Outlet bay, on the dull point which embraces the corners of sections 13, 14, 21 and 32, T. 63-17, and along the shore of the lake for half a mile westward. This shore was examined by the writer in 1887, and although at that time the same general conclusions were arrived at as to the genesis and succession of the rocks, the examination was more cursory, and the conclusions were held in abeyance until further and more detailed examination could be made. This seemed to be required by the published views of some geologists who have questioned the banding seen frequently at the points of transition from crystalline schist to gneiss, and who, like Lawson, have attributed the banding of the gneiss at such transitions, to lateral intrusion of igneous dikes along the strata planes of a mica schist. The results of this first examination are given briefly in the fifteenth annual report of the geological survey (pp. 293-94).

In reviewing the situation the following were found to be the structural features which are not compatible with the idea

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*The members of our party were, besides the writer, Dr. U. S. Grant, A. H. Elftman, and H. F. Bain, the last a member of the geological corps of Iowa.

of lateral intrusion of thin sheets of eruptive matter at this point.

1. There is an infinity of the granitic interlaminations coincident with the strata of the mica schist.

2. Sometimes these interlaminations consist largely or even wholly of quartz.

3. Sometimes they are very coarse like pegmatite.

4. Sometimes they consist almost wholly of red coarse crystals of orthoclase.

5. Sometimes the red color is not separated from the gray.

6. A dike of red granite that cuts across the strike of the schist, three inches in width, in one place shows a transition abruptly to the schist, but in following it along, the dike is seen to lose its individuality by fading out on one side into the schist and for some inches the two rocks are blended, but on the other side the contact line remained nearly as distinct. The point at which the rocks are blended is marked by an irregular spur or nodule of more perfect granite but associated with this nodule is a small mass of vein quartz, showing that the generation of vein quartz had a close causal and contemporary connection with that force which generated the more perfect granite.

7. The granitic interlaminations, which pervade the whole mass, are so numerous that they really give character and a reddish color to the whole, and where the rock is weathered it all appears red as if the schist itself had nearly the same nature as the granitic interlaminations.

8. Besides the granitic interlaminations and the approximate conversion of the whole into gneiss, the rock contains a great many irregular nodules, and lenticular masses, varying in size from that of a walnut to areas several feet across, but mostly less than six inches, which consist of granite, but which cannot be referred to a normal intrusion of molten rock. They are entirely isolated, one from the other, and they sometimes give the dark mica schist a curiously blotched aspect.

9. While the blotches assume, sometimes, elongated shapes, the elongation being usually parallel with the stratification, they are sometimes very thin, varying from a quarter of an inch to several feet.

10. These isolated masses are both fine and coarse grained, sometimes very quartzose.

11. There are very coarse pegmatyte veins, the orthoclase crystals being two or three, or even six inches on a cleavage surface, but these veins are usually in openings in the schist which are transverse to the prevalent structure.

12. There are numerous segregations that consist partly of quartz and partly of a mixture of quartz and feldspar, the latter having some dark ferro-magnesian mineral in small amount. In some cases the feldspar and quartz surround a quartz nodule, and, *vice versa*, sometimes the quartz surrounds the mixed segregation. They must necessarily have had the same origin.

13. Sometimes over large areas of the hard schist there appears to have been generated a fine feldspar. The rock is still gray and schistose, but coarser and granular, and weathers red. This is a rock intermediate between granite (or gneiss) and mica schist.

14. There is a hardening and crystallizing apparent, in some places, in all the schist, rendering it all susceptible to the name gneiss, but it is gray except on weathered surfaces, which become red, and on the parts which are of real granite.

Other characters were noted, but need not be mentioned. After considerable study as to the probable manner of origin, of this granite, I finally concluded that it is segregated chemically, and was not molten. That the schists were fractured at about the same time that this segregation took place, is evident, but at this place the filling of these openings was accomplished mainly by chemical and hydro-thermal transfusion. There may have been actual fusion by hydro-thermal forces, at some short distance from the points at which the inspection was made, and some of the fused rock may have entered some of the adjacent openings in the schist, but if it did the resultant rock is so nearly the same as that which has been generated *in situ* that it can scarcely be distinguished from it.

We have then, here, the conversion of the crystalline schist into gneiss, *in situ*, near the boundary of a great granitic boss. We have the generation of isolated granitic nodules in the schist, some of them being identical with the granite of

the great granitic boss, and some of them being pegmatyte, and hence, since pegmatyte cannot be considered as of eruptive origin, owing to the size of the crystals of which it consists, both the finer and the coarser are to be referred to chemical origin.

If now we connect these facts with the facts that are associated directly with the great granitic boss which lies adjacent we are almost driven to infer that the great granite area must have had a similar origin under more intense action of the same forces. These facts are:

1. Numerous dikes of true intrusion in the schists.
2. Occasional inclusions of schist in the granitic mass.
3. The sameness in character of these dikes and of the main boss, and of the granitic parts of the schist. This similarity is general. There are variations in both.

In general, it may be said that all this change of the schist to granite, or to gneiss, took place at considerable depth below the surface, and that these relations are now apparent at the surface because of the decay and removal of much superincumbent rock. It was a process of long duration, involving thousands of years. It took place when the internal heat of the earth was much greater, and the fusing-point isothermal ran nearer the surface. It was at a time also, in all probability, when the oceanic water covered the region with a thin aqueous layer, and when water found frequent access to the heated interior by reason of more frequent fractures and upheavals in the thin crust. Hence heated steam was abundant and available to assist in the transformation of the early sediments into crystalline forms. Once plastic or molten, such materials would flow easily, and as soon as they began to flow they constituted true igneous rock, in the ordinary acceptation of that term. It will be only a rare circumstance to find such fused rock-matter re-crystallizing again in its original place. It would move, in large masses and in small, and would make, as it does, innumerable "contacts" on the original schists, thus appearing to be always non-conformable. Such contacts, however, are not ordinary igneous contacts, for the enclosing rock is nearly of the same composition, and the same coarseness as to crystallization as the enclosed rock, indicating nearly the same temperature. When a molten rock con-

tacts on a cold rock it is chilled and crystallizes finer at the immediate contact. No such phenomena are found in these contacts.

We conclude, therefore, as already stated, that the transition from the crystalline schists to the gneiss and granite was of the nature of a gradual conformable change, accompanied by silicification, and by a change of the schists themselves to gneiss, in the first place, and finally to granite by hydro-thermal fusion, and that the granitic rock penetrated the schists by generation in them of the granitic minerals in the first place, and later, or nearer the seat of the greater heat, by actual intrusion in a molten form.

2. We come now to the second point to which I wish to call your attention, viz., *the nature and relations of the Stuntz conglomerate to Vermilion lake.*

This conglomerate forms a large island near the south shore of the lake, and is named from this island. It also spreads east and west for several miles, appearing on the mainland. It is a rather curious formation, as its pebbles consist almost wholly of one kind of rock, and that of a kind not known in the region in sufficient amount to have furnished these pebbles, viz., a gray felsyte, or quartz porphyry. The Minnesota survey has reported on this conglomerate, but without reaching any conclusion as to its true nature and origin, although latterly somewhat inclined to favor the idea of eruptive origin for the mass, the pebbles being, under that hypothesis, of the nature, originally of volcanic bombs, and the cement of the nature of volcanic ash. This view, however, has never been published.

About a year ago a paper was published in the Transaction of the American Institute of mining engineers,* whose authors proposed a new and remarkable hypothesis for the origin of this conglomerate, which if true, taken in connection with all the attendant consequences, as detailed by them, would require very important, and even sweeping changes in the geology of the region as it has been supposed to exist, and as reported by the Minnesota survey. They advocate the view that this rock is not a conglomerate, but a breccia. They consider it as a

*SMYTH AND FINLAY. Geological Structure of the western part of the Vermilion range, Minnesota. Tran. Am. Inst. Min. Eng., Atlanta meeting, pp. 51, 1895.

massive acid rock originally, which cut the rocks of the iron-bearing formation. Subsequently they suppose that this massive rock has been presssed and broken and sheared. They suppose three or four directions of shearing in order to cut the rock into cuboidal blocks along certain planes of movement and a continued frictional movement along the same planes after the rock was cut, thus breaking off the angularities of the blocks and surrounding them by a matrix which they poetically style the "flour of attrition." When sufficiently rounded the blocks and the flour were then consolidated and became the Stuntz conglomerate.

Our party carefully reviewed the whole subject. They not only found that the rock is a true conglomerate, but also discovered its basal contact on the iron-bearing formation. Instead of being associated with the iron-bearing formation, and older than the slates and the graywackes, it is of the same formation as the slates and graywackes, and lies unconformably on the iron-bearing formation. We also found that the composition of the conglomerate is not uniform—as it must be if it have the origin presumed by the authors of that hypothesis. Not only do the felsyte pebbles vary in grain, even those in contact in the mass, some being porphyritic and others not, some being of a darker color lying beside those of a light color, but they are of different sizes, though in contact, rendering the shearing and cutting motion if it took place, one of multiple planes instead of definite ones, and of short and varied application instead of continued and rigid.

We also found, what is most convincing, that the bottom of this conglomerate, when it lies on the jaspilyte of the region is composed almost entirely of fragments from the jaspilyte. Messrs. Smyth and Finlay admit that, on their hypothesis, the intrusion of the acid eruptive may have torn from the strata through which it passed, fragments of the jaspilyte, and might even carry them some distance in the direction of the flow. It is in that manner that they account for fragments of the jaspilyte which they found in the conglomerate. That may be admitted. But we found the conglomerate to consist, in the proportion of 9 to 1, of fragments of jaspilyte at a point 10 feet from the contact. It is hard to believe that an acid rock composing but one-tenth of a mass would be able

to transport even ten feet, the remaining nine-tenths. Further, we found that this conglomerate graduates into a quartzyte, and into a graywacke and that the graywacke graduates into argillaceous slate, these latter constituting, with the conglomerate, an upper formation nonconformable on the iron-bearing formation.

This discovery not only corrects Messrs. Smyth and Finlay, but corrects also the Minnesota survey, for the Minnesota survey had not before recognized this plane of non-conformity, although it had been claimed to exist in that region by Prof. C. R. Van Hise of the United States Geological Survey.

The importance of this discovery is so great that it is not possible to discuss its effects on the structural geological scheme of the state at this time. Whether this break in the stratification be a northern representation of that which exists at the base of the Taconic, or an older one which thus would really make an important new formation in the Archean, is not yet ascertained.

3. There remains now the third point which I will allude to but briefly, viz: *the nature and position of the conglomerate in the Puckwunge valley.*

North from Grand Portage village is a stream entering the Pigeon river from the west which the Indians call Puckwunge. Along the side of this valley is a conglomerate and quartzyte, in the northern slopes of the hills which form the southern barrier of the valley. This conglomerate, which has been twice examined, remained until the recent visit, somewhat of a puzzle. It is not where a conglomerate has been expected. It undoubtedly forms the base of a formation, either of the Animikie or of the Keweenawan. It is overlain by igneous rocks resembling the traps of the Keweenawan. What it exactly lies upon we could not find out, but in a lower level in the same hills is a singular-looking and somewhat slaty rock which we named the Puckwunge slate. This slate is an important formation. It extends far northward, at least across the Puckwunge valley, and eastward. It forms the outcropping rock seen at several places on the Grand Portage trail, except near Grand Portage village where the usual features of the slaty Animikie are seen. The drift is rather heavy in the region, and it was only by general taxonomic

considerations that we reached the tentative conclusion that this slaty rock is an upper member of the Animikie not before individualized by the survey, nor indeed before mentioned by any geologist. It is over this soft, slaty, greenish rock, that the Puckwunge conglomerate belongs.

This conglomerate consists of quartzyte pebbles, for the most part, but this quartzyte varies in color from white to pink and to red. These are not perfectly characteristic, but are referable to the quartzytes that are a large feature of the Animikie in the hills next further north. We gathered an assortment of these pebbles, and shall make further examination of them. We sought in particular for the well-known taconyte pebbles, which would show this conglomerate to be later than the ores of the Mesabi iron range, hence later than the Animikie, and although the specimens have not yet been examined microscopically, two or three of them appear to be of that peculiar kind of pebbles.*

The importance of this discovery is also great. It extends to a region not before suspected the basal conglomerate of the Keweenawan. This conglomerate is known at the base of Grand Portage island and more recently we have identified it. tentatively, along the lake Superior coast, at intervals, from Baptism river to near Beaver bay, and further east. It is a valuable guide to the separation of the older Norian eruptives from the true Keweenawan. I have recently brought this subject out fully in a series of papers in the AMERICAN GEOLOGIST, and it is not necessary to dwell on it again.†

These three important observations and that relating to the nature of the contact of the Saganaga granite on the Ogishke conglomerate, were the results of a three weeks' trip late last fall. They show that it is necessary to proceed very carefully in drawing general conclusions as to the geological structure of that portion of the state. Our work has shown the geographic distribution of the formations, but it has not been sufficient to show, in all cases, the chronologic order and the genesis of the rocks that we have described.

*Thin sections have later been examined. They show the peculiar crypto-crystalline silica of the rock taconyte, but not the usual amount of iron oxide. They are referable to the Animikie.

†A rational view of the Keweenawan. AM. GEOL., XVI, 150, 1895.

EDITORIAL COMMENT.

MAN AND THE MEGALONYX IN NORTH AMERICA.

Mr. H. C. Mercer has been exhuming what are probably the last relics of the Megalonyx which has been from time to time partially disentombed from the Big Bone cave in Van Buren county, Tennessee, and has given an account of the work in the last number of the Proceedings of the American Philosophical Society. The first found specimens came to light in 1835, the next in 1864, and these last in 1896, by an expedition sent out from the University of Pennsylvania with the object of determining the antiquity of man by correlating his remains with those of some of the extinct mammalia of North America. The cost of the expedition was generously defrayed by the vice-president of the university, Dr. William Pepper.

This and other caves had been rifled for saltpetre during the wars of 1776, 1812, and 1863, and the relics of the Megalonyx were found at the very end of one of the subterranean galleries after all the earth had been removed up to that point. Hence they were not much disturbed.

Mr. Mercer deserves much credit for his perseverance in the difficult and excessively unpleasant task of the disinterment of the bones. They were completely embedded in a layer of dung of the cave-rats which have evidently frequented the cave from time immemorial. But the results add nothing to our knowledge of ancient man. No evidence of his presence was discovered with two doubtful exceptions which will be mentioned later. The skeleton lay a thousand feet from the entrance where the cave is perfectly dry and dusty and where, unfortunately several openings exist to the surface through which much of the lighter material may have been carried in. Though the deposit can be divided into several layers with much distinctness it is obvious that in a dry cave that is frequented by rats and porcupines and has been ransacked again and again for saltpetre there must exist much uncertainty regarding the relation of objects merely buried in the dry rats' dung in a layer thirty inches thick and only covered with another two inches in thickness.

But in fact the explorations tend to show rather the recen-

cy of the Megalonyx than the antiquity of man. As Mr. Mercer says (p. 70): "We have modernized the fossil sloth if we have not definitely increased the antiquity of the Indian hunter whose first coming the animal doubtless witnessed in the woods of Tennessee."

This is strongly confirmed by the very modern appearance of the bones, some of which yet show traces of their cartilaginous attachments—a circumstance by no means unknown in similar finds.

The total absence of stalagmite deprives us of the strong argument, that proved unanswerable in the case of Mr. Pengelly's reports on Kent's cave, by separating the layers by impermeable barriers of limestone and thus preventing confusion. It is consequently impossible to extract satisfactory evidence in the present instance. This is obvious from such facts as the following: the occurrence among the specimens older than the bones of the body of a fly identical with a European species and very probably introduced to the continent by the white men, though of this entomologists are not sufficiently sure. Mr. Mercer says (p. 67) "According to the order of formation of the different refuse the lower layer preceded the upper and the gnawed nuts, the seeds, the fly preserving intact its delicate wings comparatively modern as they seemed, had reached their position before the deposition of the bones."

The paper is excellently illustrated with figures of the cave and the bones, but can hardly be said to be valuable as an addition to our knowledge of the subject. It is especially disappointing to read that the only two objects found which might possibly be regarded as indicative of the presence of man (though very doubtful ones at best) namely, a small fragment of maize-silk and a single sunflower seed, are deprived of value by the possible introduction of the former during the excavation and a mischance in affixing labels on the latter.

A curious mistake or perhaps misprint occurs on the last page where percolating lime is mentioned as filling the cavities. It is difficult to imagine any such substance in a limestone cave or anywhere else in nature and we cannot but regard it as an error for carbonate of lime.

Mr. Mercer also seems to be unaware of the existence of the Megalonyx found in Holmes Co., O., in 1890 and described in

this journal in February, 1891. Eighty bones were obtained and the remainder are doubtless still lying in the peat that rests upon the glacial gravel and prove by their position their postglacial date. The bones are now set up and form one of the most valuable treasures of the museum of the Ohio State University at Columbus.

The Megalonyx, being on the above evidence certainly postglacial in North America, it would surprise no one to learn that the remains of man should be found in association with its bones. But early man in America does not seem to have frequented caves as dwellings as freely as did his European relations. At least American caves have as yet yielded little evidence of value proving human occupation or association with cave-dwelling animals either recent or extinct. E. W. C.

A TRIBUNAL OF FINAL APPEAL SHOULD BE INDEPENDENT OF ALL INFLUENCE.

It is a somewhat significant fact that with the exception of the 1st (Paris), 2d (Bologna), and 4th (London) sessions of the International Congress of Geologists, every other has been under the influence and auspices of the "official geologists" of the "official geological survey" of the particular country where the Congress was held. Yet at Berlin it was plainly declared in the Bureau that every respectable bona fide geologist had the right to a seat in the Congress: and on the question arising what weight a vote of the body would carry when usually over half the members were from the country where the Congress was held, and for various reasons some of the countries most important geologically might not be represented at all or very insufficiently (i. e. Germany at a Congress in France and vice versa), it was answered that each country should have one vote on every question, and the nature of that vote should be determined by a caucus of the members from that country.

The clumsy but ultimately successful attempt of major J. W. Powell and others of the U. S. Geological Survey to change the place of meeting of the 5th session from Philadelphia, (where a unanimous vote of the London Congress had decided it should go) to Washington; and the dismal failure of that session in number of foreign visitors, management of excursions, and character of the volume issued, is well known

abroad as well as here. A pernicious influence must have been exerted on our sister republic of Switzerland, for at the Zurich meeting for the first time the cabal of international officialism began to abandon disguise. It was proclaimed by the presiding officer for the first time that two out of a number of members from a certain country were "delegates," because they each had a letter from the "official geologist" of the country recommending them as representatives of the "official geological survey." Thus the anomaly was presented of an employe of the Interior Department of his own land designating who should sit as a representative of that land in the council of the Congress. It was for this reason that the writer offered the resolution requiring the next bureau to define who were "delegates," and who were authorized to appoint them.

This resolution was unanimously carried by the Council. But owing to a practice which may possibly be due to the desire of the international geological trust to perpetuate itself, the volume containing the papers and transactions of one meeting is held back till just before the next meeting, or three years; indeed many of those who attend a meeting of the Congress see the volume of the preceding meeting only on returning to their homes. This prevents concerted action and puts off for six years any possibility of correcting an error which may occur in the volume. The translation of the resolution (which appears in the printed record of the 3d session of the council, Friday, Aug. 31, 1894) appeared in this journal in 1894, and is as follows: "The Bureau of the Congress will consider the following questions and will reach decision in time to apply it to the organization of the next Congress.

"1. To what extent does the Congress recognize the right of governmental bureaus, as such, of societies, or of any kind of organizations, to send representatives to the Congress?

"2. Within what limitations does the Congress recognize the right of such representatives or of only a portion of the members of the Congress coming from the same country to designate who shall be the vice-president representing their country, or to take any other steps (in the name of their country) without consultation with all their countrymen members of the Congress?"

The prospect that our Russian brethren will give the coup

de grace to this bureaucratic, self-perpetuating practice is not very bright, but by the terms of the resolution some action must be taken by the Bureau, which should be made the basis of an organized effort by all freemen to kill favoritism of every kind and throw open the Congress to all geologists alike. It would be very significant if this reform step were taken in St. Petersburg. P. F.

PALÆOZOIC GLACIATION.

In the Quarterly Journal of the Geological Society Mr. Aubrey Strahan gives an account of a recent visit to Norway to examine the so-called glacial phenomena of the Varanger fiord. His report fully confirms that of Dr. Reusch, and there is now no standing-ground for maintaining any opposing opinion.

His report and his photographs must be regarded as decisive. The planed and smooth rock face with a lenticular mass of genuine boulder clay lying on it, and covered in turn with a second layer of similar quartz grit, are as clearly of glacial origin as are the boulder-clays of our recent glacial era. So close is the resemblance that were it not for the important deductions consequent upon the admission, hesitation would be impossible. Microscopical examination has shown that the quartz-gravels in the indurated boulder-clay or boulder-rock have been enlarged by secondary deposition in optical continuity, just as those in the Waverly quartz-grits have been rejuvenated with the same material. Regarding the exact age of these beds in the absence of fossils, the palæontologist can give no opinion. But the researches of the Norwegian geologist lead to the belief that all these strata are overlain with beds holding the *Olenellus* fauna, and therefore of the age "of the basal Cambrian quartzite or they may be even as old as the Torridon sandstone."

Previous results in India and Australia have prepared us to look for signs of glaciation even under the equator in days as distant as the Carboniferous era. Norway, or at least Varanger fiord, is, on the other hand, close to the Arctic circle. Yet the occurrence of ice so far down in the rock and so long ago as the oldest Cambrian or pre-Cambrian time is not a little surprising. In any case, this ice action must be coeval with

the earliest known life, and if the rocks are of Torridonian age it must even antedate the deposition of those ancient hitherto Azoic strata of Scotland. The theoretic deductions herefrom are many, striking and important. E. W. C.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Pleistocene Features and Deposits of the Chicago Area. FRANK LEVERETT. (Bulletin of the Chicago Academy of Sciences, 1897.) This paper contains a summary of Mr. Leverett's work upon the moraines and drift sheets of the country lying within about 100 miles of Chicago. It gives an account in considerable detail of the various lines of drift material as they are now growing more distinct and distinguishable under careful and persistent scrutiny, to which result Mr. Leverett's own labors have in a very large degree contributed. He recognizes the following series of successive glaciations: 1. The Albertan or oldest (of Dr. G. M. Dawson) which has not been found in the district. 2. The Kansan, to which belongs great part of the drift sheet of southern Iowa and Missouri, which also scarcely enters the area. 3. The Illinoian, which includes a sheet covering western Illinois and a small part of southeastern Iowa. 4. The Iowan "upper till" of McGee, contemporaneous with the great "loess" sheets of the west. 5. The early Wisconsin with four substages indicated by minor moraines, and 6, The later Wisconsin with three substages, including the massive Valparaiso system skirting the southwestern shore of lake Michigan.

Mr. Leverett reviews the evidence regarding the relative dates of these various ridges which is drawn from the amount of erosion, leaching, intermediate soil, and forest growth and other sources. The data indicate a succession of ice-invasions from different sources, the most extensive of the series overriding the deposits of the earlier ones and to a great degree or altogether defacing them, while those that followed left on the surface their terminal moraines and other monuments to indicate the limits of their southern advance. In this way a rudely concentric stucture of massive but gently sloping ramparts was built up around the south end of lake Michigan and other salient points on the northern line of the ice-front, the tracing of which is the subject of the present work. The paper is illustrated with several maps and some good photographic reproductions of exposures in the works of the Chicago drainage canal, etc., (most of which are the work of Gayton Douglass of Chicago) and the author closes with a discussion of the present changes going on around lake Michigan and the lapse of time which they express.

E. W. C.

Papers and Notes on the Genesis and Matrix of the Diamond. By the late HENRY CARVILL LEWIS; edited from his unpublished manu-

scripts by PROF. T. G. BONNEY. Octavo, 72 and xvi pp., three plates. $2.50. Longmans, Green & Co., New York, 1897. This is the second of Prof. Lewis' works issued posthumously by Mrs. Lewis. It shows the versatility of Prof. Lewis' genius. It stands at that end of the science at which is required the greatest preliminary study and the most patience and skill with delicate apparatus, as the other stood where the least is required. These two works attest the affectionate fidelity and remembrance of her whose close sympathy and aid must have been one of his chief incentives.

To the original papers of Prof. Lewis, which he read before the British Association for the Advancement of Science, Prof. Bonney has made valuable editorial minor emendations and has added brief macroscopic and microscopic descriptions of some specimens from America found amongst the materials left by Prof. Lewis. This friendly editorial service has been done by Prof. Bonney in lieu of Prof. G. H. Williams, to whom it was entrusted by Prof. Lewis during his last illness, but who died from the same disease (typhoid fever) before he was able to accomplish the charge.

The remarkable rock containing the diamonds found at Kimberley, South Africa, was named kimberlyte by Prof. Lewis. He found it contained the following minerals, many of them only in microscopic quantities.

Olivine, forming the larger portion of the rock, often quite fresh.

Enstatite, *chromo-diopside*, *smaragdite* and *bastite* often in fine green plates or crystals.

Biotite, a very prominent ingredient.

Garnet, common in bright red grains.

Perovskite, abundant in microscopic crystals.

Magnetite, *chromite*, *ilmenite*, *picotite*, common under the microscope.

Apatite, *epidote*, *orthite*, *tremolite*, *tourmaline*, *rutile*, *sphene*, *leucoxene* (scarce and minute).

Serpentine, *calcite*, *zeolites*, *chalcedony* and *talc* as decomposition products. Also an undetermined mineral, probably *cyanite*, and finally *diamond* (scarce).

The rock embraces many inclusions of rock-fragments, such as shale, diabase, granite, gneiss, eclogyte and of other rocks, but those of shale are by far the most numerous, sometimes constituting the greater portion of the rock.

Kimberlyte is a decayed and brecciated peridotyte and exists in the crater and "pipe" of an extinct volcano. and is now mined at a depth of over 1500 feet. Its structure resembles the chondritic structure of stony meteorites, due, as supposed by Lewis, to frequent and continued explosive jars during the activity of the volcano. The adjoining black shale is bituminous and charged with pyrite, but those fragments which are enclosed in the kimberlyte have lost their shaly character, their carbonaceous matter and their sulphur. It is to these shale fragments that Lewis attributes the origin of the diamond, through the concentra-

tion in the basic rock of the carbon without the access of sufficient oxygen for carbonic acid.

Prof. Bonney describes with citation of Williams and Diller, the kimberlyte of Syracuse, N. Y., and of Elliott county, Ky. These present a very close macroscopic and microscopic resemblance to the diamond-bearing rock of South Africa These also embrace many foreign fragments, among which shale predominates. The Syracuse rock was described by G. H. Williams in the Bulletin of the Geological Society of America, I, 1890, p. 533, and the Elliott county rock by Mr. J. S. Diller in Bulletin 38 of the United States Geological Survey, 1887. N. H. W.

RECENT PUBLICATIONS.

I. Government and State Reports.

N. Y. State Museum, 48th Ann. Rept., 3 vols., 1895. Vol. I contains the following Bulletins: Clay industries of New York, Heinrich Ries; The geology of Moriah and Westport townships, Essex Co., N. Y., J. F. Kemp: Mineral Resources of New York state, F. J. H. Merrill. Vol. II (Report of State Geologist) contains: A preliminary description of the faulted region of Herkimer, Fulton, Montgomery and Saratoga counties, N. H. Darton; Report on the structural and economic geology of Seneca county, D. F. Lincoln; The principles of palæontology, Felix Bernard. Development and mode of growth of Diplograptus, McCoy, R. Ruedemann; A revision of the sponges and cœlenterates of the Lower Helderberg group of New York, G. H. Girty: The new species of Brachiopoda described in Palæontology of New York, vol. III, pts. 1 and 2; A handbook of the genera of the North American Palæozoic Bryozoa, with an introduction upon the structure of living species, G. B. Simpson.

II. Proceedings of Scientific Societies.

Trans. Canadian Inst., vol. 5, pt. 1, Oct. 1896. The fluctuations of lake Ontario. Kivas Tully; Rainfall and lake levels, R. F. Stupart.

Bull. Geol. Soc. Amer., vol. 8, pp. 305-314, 31-39, Apr. 14, 1897. Nature, structure and phylogeny of Dæmonelix, E. H. Barbour.

Ibid., pp. 315-358, pls. 40-50, Apr. 15. Upper Cretaceous formations of New Jersey, Delaware and Maryland. W. B. Clark.

Ibid., pp. 359-446, pl. 51, April 30. Memoir of Robert Hay, R. T. Hill; Memoir of Charles Wachsmuth, Samuel Calvin; Memoir of N. J. Giroux, R. W. Ells; Note on the stratigraphy of certain homogeneous rocks (abstract), C. H. Hitchcock: Aporhyolite of South Mountain, Pa., Florence Bascom: Age of the white limestone of Sussex Co., N. J., (abstract), J. E. Wolff and A. H. Brooks; Origin and relations of the Grenville-Hastings series of the Canadian Laurentian, F. D. Adams and A. E. Barlow; Note on "Origin and relations of the Grenville-Hastings series of the Canadian Laurentian," R. W. Ells; Grain of Rocks (ab-

stract)A. C. Lane; Physiography of the eastern Adirondacks in the Cambrian and Ordovician periods, J. F. Kemp.

Bull. Essex Institute, vol. 27, nos. 7-12 (July-December, 1895), 1897. Supplementary report on the mineralogy and geology of Essex Co., J. H. Sears; Sandstone dikes accompanying the great fault of the Ute pass, Col., W. O. Crosby.

Proc. Portland Soc. Nat. Hist., vol. 2, pt. 4, 1897. The Foraminifera of the marine clays of Maine, F. S. Morton.

Proc. Canadian Inst., new ser., vol. 1, pt. 2. May, 1897. Mineralogical notes on Sudbury anthracite, G. R. Mickle; Chemical notes on the so-called Sudbury coal, W. H. Ellis and Wm. Lawson.

Chicago Acad. Sci., Geol. and Nat. Hist. Survey, Bull. 2, 87 pp., 2 pls., May, 1897. The Pleistocene features and deposits of the Chicago area, Frank Leverett.

III. Papers in Scientific Journals.

Science, May 14. Former extension of Cornell glacier near the southern end of Melville bay. T. C. Chamberlin; The loess formation of the Mississippi region, O. H. Hershey.

Ibid., May 21. The recent visit of Sir Archibald Geikie, J. F. Kemp: Sir Archibald Geikie on a comparison between the Tertiary volcanic succession in northwestern Europe and in western America, W. F. Morsell; Current notes on physiography, W. M. Davis; Former extension of ice in Greenland, R. S. Tarr.

Ibid., June 4. Current notes on physiography, W. M. Davis; Glacial man in Ohio. C. B. Morse.

Ibid., June 11. The introduction of new terms in geology, J. C. Branner; A question of classification, R. T. Hill.

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Ottawa Naturalist, April. Contribution to the palæontology of the post-Pliocene deposits of the Ottawa valley, H. M. Ami.

Appleton's Pop. Sci. Monthly, June. World's geologists at St. Petersburg, W. H. Ballou; Sketch of Richard Owen, D. S. Jordan.

Nat. Geographical Mag., May. Applied physiography in South Carolina, L. C. Glenn.

Amer. Nat., June. Toxodontia, E. D. Cope; on the characters of Macropetalichthys, C. R. Eastman.

Jour. of Geol., May-June. The last great Baltic glacier, James Geikie; The post-Pleistocene elevation of the Inyo range, and the lake beds of Waucobi embayment, Inyo Co., Cal., C. D. Walcott; Italian petrological sketches, summary and conclusions, H. S. Washington; Variations of glaciers, H. F. Reid; A sketch of the geology of Mexico, H. F. Bain.

IV. Excerpts and Individual Publications.

Pleistocene Iowa, S. Calvin. Annals of Iowa, ser. 3, vol. 3, no. 1, pp. 1-22, April, 1897.

The Tennesee phosphates. C. W. Hayes. 17th Ann. Rept., U. S. Geol. Survey, pt. 2, pp. 513-550, pls. 50-55, 1896.

History of the discovery and report of progress in the study of Daemonelix, E. H. Barbour. University (Nebraska) Studies, vol. 2, no. 2, pp. 81-124, pls. 1-18, January, 1897.

Notes on the chemical composition of the silicious tubes of the devil's corkscrew, Daemonelix, T. H. Marsland. Ibid., pp. 125-130, Jan., 1897.

A short history of the Great Lakes, F. B. Taylor. "Studies in Indiana Geography," 21 pp., May, 1897.

Report of the section of chemistry and mineralogy, G. C. Hoffman. Geol. Survey of Canada, Ann. Rept., vol. 7, pt. R, 59 pp., 1897.

The gold-quartz veins of Nevada City and Grass valley districts, Cal., Waldemar Lindgren. U. S. Geol. Survey, 17th Ann. Rept., pt. 2, pp. 1-262, pls. 1-24, 1896.

The building materials of Pennsylvania, I, Brownstones, T. C. Hopkins. 122 pp., 26 pls., appendix to Ann. Report of Pa. State College for 1896; 1897.

Report on explorations in the Labrador peninsula among the East Mair, Koksoak, Hamilton, Manicuagan and portions of other rivers, A. P. Low. Ibid., pt. L, 387 pp., 4 pls., 4 maps, 1896. With an appendix. Notes on the microscopic structure of some rocks from the Labrador peninsula, W. F. Ferrier.

A treatise on rocks, rock-weathering and soils, G. P. Merrill, ix and 411 pp., 25 pls; The Macmillan Co., New York, 1897.

V. Proceedings of Scientific Laboratories, etc.

Memoirs Museum Comp. Zool., vols. 20 and 21, with atlas; ix and 837 pp., 83 pls., May, 1897. The North American Crinoidea Camerata, Charles Wachsmuth and Frank Springer.

CORRESPONDENCE.

THE HEMPSTEAD PLAINS, LONG ISLAND, N. Y. When I first began the study of the drift phenomena on the west end of Long Island, I was led to suspect that the formation of the Hempstead plains was due to the breaking through of the glacial waters at Roslyn, as west of this point the glacial rivers seemed to be more confined to the north side of the island, behind the terminal moraine. A visit to the plains in question during the summer of 1882 seemed to confirm this conjecture for everywhere, as Warren Upham says, the moraine seemed buried by fluviatile gravel and sand.

On a recent visit. however, to this locality, I discovered a well defined kame-like moraine at East Williston, a little to the north of Mineola. It does not form a very conspicuous feature in the topography of the plains, yet the Roslyn branch of the Long Island railroad makes quite a deep cut through it. The erratics scattered over the surface show plainly that the ice sheet must have advanced to this point.

It would be difficult, perhaps, to trace out one continuous moraine across the plains, as in places there is only a slight fringe of boulders to mark the southern limits of the glacier.

During my recent visit, however, I was able to follow up the Williston ridge to the east as far as the main line of the Long Island railroad some two miles south of Westbury. Here the moraine is somewhat broken and a second ridge appears about half a mile to the north, more prominent than the one I had traced out from Williston. I walked along the railroad track across what seemed to be an old water channel or lakelet and found the Westbury moraine, very much like the first, chiefly composed of stratified gravel and sand; the material was somewhat coarser, perhaps, and the boulders on the surface were larger and more abundant.

The railroad makes quite a deep cut through it, and then enters a level plain which stretches out to the northern series of hills. The second beach-like ridge seems to form the northern margin of the old water channel referred to, and continues unbroken as far as the village of Hempstead where other old glacial river channels are met with. On leaving the railroad track, about a mile south of Westbury, the boulders begin to disappear from the surface so that this ancient beach seems to be both inter-morainic and extra-morainic; but I found no difficulty in tracing it, as the old water channel is continuous and plainly visible the whole of the distance from the railroad to Hempstead village, where an outlet to this lake-like depression took place. The town waterworks are situated at the mouth of the old water channel. The depression has been deepened somewhat and a small stream of water is flowing through it, a tiny representative of a once powerful river. The dark, peat-like formation covering the underlying gravel is about eighteen inches in thickness, which gives us some idea of the extent of postglacial time.

The Williston ridge, or beach, doubtless formed the southern margin of this glacial stream or lake, but it seems to be more broken than its northern neighbor, and is not so easily defined. I did not have time to follow it up, however, in its entirety, but there is no question of its existence, as it is well developed at Williston, as stated, and there can be no doubt but that the ice-sheet advanced to this point.

The line of the terminal moraine has generally been drawn back as far north as Roslyn, although the present writer has always maintained that the moraine did not recede, but only disappeared. The discovery of the Williston ridge seems to verify this statement, and a careful survey, I think, will establish a terminal morainic line—an attenuated glacial border across the plains from Hainsdale eastward to Farmingdale some six miles south of northern series of hills. Of course, the "back-bone" as the terminal moraine is called, becomes very much disjoined between the two points named, but this is nothing unusual, as the same phenomenon occurs in other glaciated regions.

The report of the geological survey of New Jersey, 1893, on page 149, contains a description which might be applied to the Hempstead plains.

It says: "From Buttzville westward the stratified drift forms the lar-

ments are always found in stratified deposits, but never in the unmodified drift. One would naturally suppose that an ice sheet grinding and carrying with it the rock and other *debris* from the surface of the land over which it passed would have embosomed in it some of the wreck of the forest lands, but there is no such indication in the drift of Long Island. I mean, of course, the unmodified drift, for, as stated, the wood fragments have only been found in the overwash or beneath it. Lignite found at greater depths, nearly 400 feet below the surface, may be older and of different origin than the wood fragments referred to, although the late curator of the Long Island Historical Society, Mr. Lewis, says of it: "The lignite found threw no light on the age of the beds. It is brought to the surface in small pieces and that from the surface of the clay bed 353 feet was formed from small stems of exogenous structure. The same is true of that found at 70 feet. This deposit of clay 56 feet in thickness seems closely analogous to many clays now upon and at various depths beneath the surface of the island. It is evidently a local deposit such as might occur in a depression of the surface. Two tube wells have been driven at no great distance from Barnum's island, one 97 the other 194 feet, in which no similar layer of clay was detected." This was said in reference to the boring on Barnum's island, which may be said to form part of the Hempstead plains. The same is also true of the Woodhaven well near Jamaica bay where the rock *in situ* was reached at the depth of 550 feet. Fragments of wood and lignite were found at the depth of over 300 feet in a stratum of clay 10 feet in thickness. Nothing of a marine character was found. In fact, very little of an organic nature could be detected.

Both of the deep wells were failures so far as a supply of water was concerned, which would seem to disapprove Mr. Darton's theory, that there is a substratum of water flowing from the main land underneath the sound and across Long Island sufficient to supply the whole of the city of Brooklyn. A few experiments have been made and a few flowing wells have been struck on the Hempstead plains, but their success has not seemed to warrant a greater expenditure of money. I have before me a copy of a letter written by Mr. Carmen, an experienced well digger of Hempstead, in relation to the well boring on Barnum's island in the Great South bay near the ocean. He says: "The first five feet was coarse sand and gravel, the water was fresh. The next fifty feet the soil was in layers of sand and clay. The water was salt, with creek mud and bilge water. We then passed through a very dense layer of blue clay for 70 feet with no water in it. We had to bore through it with augers and lift it out like putty. At one hundred and three feet we reached fresh water again, but in small quantity and very poor in quality. We continued to three hundred and sixty-five feet through layers of sand (beach) and clay and found no good water. We found quantities of 'sulphur stones' and particles of decayed wood or bark of trees, some of these an inch long and one-half inch thick. There have been wells put down near our village (Hempstead) about three hundred feet, some of them have been flowing wells. The water would be good

for about a hundred and twenty-five feet, and then the water would not be so good." This statement of Mr. Carman is all the more interesting at present as Mr. N. H. Darton of the U. S. Geological Survey, already referred to, seems confident that an unlimited supply of water can be found from those subterranean sources.

The natural reservoir rises only to the level of the ocean, and reaches down to the clay bottom underlying the sand and gravel. These clay beds, however, as Mr. Lewis has shown, are not very uniform and are found at various depths. In the Woodhaven well, near Jamaica bay, a layer of bluish clay containing pebbles, was struck at the depth of 247 feet, while according to Mr. Carman's statement a seam of blue clay 70 feet in thickness was encountered in the Barnum's island well at the depth of 55 feet. Very little water was found in these clay deposits.

It is encouraging to find that the attention of the U. S. Geological Survey has been directed toward our little isle by the sea, for she seems to have been sadly neglected in the past. It is to be hoped that a thorough examination will be made, not only of the subterranean water sources at present in force, but of the old water ways that played such an important part not only in the formation of the Hempstead plains, but in the building up of the whole island. JOHN BRYSON.

Eastport, Long Island, N. Y.

THE NIPISSING-MATTAWA RIVER, THE OUTLET OF THE NIPISSING GREAT LAKES.* When the waters of lakes Superior, Michigan, and Huron were making the Nipissing beach, their outlet was eastward over the Nipissing pass at North Bay, Ontario, to the Ottawa valley. This outlet river is called the Nipissing-Mattawa river and the three upper great lakes of that time are called the Nipissing great lakes. Mr. G. K. Gilbert visited North Bay in 1887, Prof. G. F. Wright in 1892, and the writer explored some of the ground at North Bay in 1893, and more, with a visit to Mattawa, in 1895. Last autumn a canoe trip of six days in fine weather was made from the head of Trout lake to Mattawa, thus covering the whole length of the Mattawa valley.

The Nipissing beach is well developed at North Bay at an altitude of about 700 feet above sea level. On the present col at North Bay the old outlet bed is somewhat over a mile wide, 30 to 35 feet deep at the maximum and perhaps half that on the average. The average here, however, is not easy to get, for there was an archipelago on the south side, and not much is known as to the number and capacity of the old channels between the islands. The first swift water of the ancient outlet was at the foot or east end of Trout lake about 12 miles east of North Bay. The Nipissing beach though faint can be followed to the foot of Trout lake.

The effects of the flowing current of the ancient outlet river are well marked at several points. The places of several ancient rapids and one cataract were found. The cataract was at the present Talon chute and the four most notable rapids were (1) below Turtle lake, (2) below a lake

*Abstract of paper read at Washington, December, 1896.

called Pimisi bay, (3) at the modern Des Epines rapids, and (4) at Mattawa. The falls were 25 to 30 feet high and the postglacial gorge made by them is very distinct. It is not quite half a mile long, but it is deep and averages only about 300 feet in width. The walls are of red granite and vertical 40 to 100 feet. A thin and highly inclined bed of crystalline limestone, passing down into the gorge from the west, may have hastened the cutting somewhat. The ancient river was expanded to a lake in the lake Talon basin, and made faint but distinct shorelines by wave action. One is 20 feet above the present lake and the other ten or twelve feet higher. The mark of the surface level of the river was quite plain at some of the rapids. On the north side at Des Epines rapids this mark is 55 feet above the present river. The channel at that level was between 600 and 700 feet wide and averaged 35 to 40 feet in depth, and the current was strong enough to move gravel and pebbles of small size. This corresponds in a general way with the size of the modern St. Clair river.

Ancient rapids were recognized in three ways. There are several narrow passages that are heavily bowlder-paved. They mark the points where moraines cross the channel. At Des Epines and Mattawa the bowlders of gneiss and granite are worn and scoured into many curious forms. Many were found with basins or potholes bored in them and a few bored clear through so as to become ring-bowlders. At each of these rapids a stream enters just above and furnished a constant supply of graval, sand and pebbles for the current to roll over and among the bowlders. The rapids below Turtle lake and Pimisi bay are of the same sort, except that the water issued from lakes, and so had no supply of gravel to scour with. The third way of recognizing rapids was by inference indirectly. Such rapids were in narrow defiles or canyons with walls of bare rock and the fact that rapids had existed there was inferred from the observed drop in the surface level of the river above and below. The remains of the Nipissing-Mattawa river agree with the Nipissing beach in indicating that the Nipissing great lakes endured for a relatively long period of time. And so long as it lasted, Niagara had only the discharge of lake Erie. A detailed account of the scoured bowlders appeared in the March number of the American Journal of Science. F. B. TAYLOR.

"THE TERM PECATONICA LIMESTONE." In his article on the "Nomenclature of the Galena and Maquoketa Series," in the May number of this journal, Dr. F. W. Sardeson refers, in somewhat sarcastic language, to my application of the term "Pecatonica limestone" to that portion of the stratigraphic series of northwestern Illinois which is designated the "Buff limestone" in the reports of the Illinois geological survey. He remarks of it: "A new name the use of which scarcely accords with scientific usage, since that author neither defines the term Pecatonica limestone nor seemed to have any reason for introducing a new name. He was discussing an entirely distinct subject and so far as I can learn, he had no more occasion to introduce a new name for a

part of the Ordovician, than one who is writing on the Ordovician would have to suggest a new name for some part of the Pleistocene." From the above language and a foot-note, I infer that Dr. Sardeson had in mind only a use of the term in a table of bed-rock formations in a paper published in the August, 1896, number of the AMERICAN GEOLOGIST. Without defending the use of the term, the retention or rejection of which is a matter of indifference to me, I desire to call Dr. Sardeson's attention to the fact that it was first used by me in a paper on "The Elk Horn Creek Area of St. Peter Sandstone in Northwestern Illinois," which appeared in the September, 1894, number of this journal. The paragraph in which it is introduced is as follows: "*The Buff limestone*. This underlies a narrow strip skirting the sandstone on its southern and western side. It is moderately thick bedded, buff or light brown dolomite, argillaceous, and nearly free from fossils. Its thickness is about 20 feet, thinning out to the northeast. It passes, by insensible gradations upward into the Blue limestone and downward into the St. Peter sandstone. Hence its lower portion is very sandy and sometimes shaly. Its designation as Buff limestone is deceptive, for under cover it is just as frequently blue as the Trenton above it. Perhaps the term Pecatonica limestone would be more appropriate, as it is best exposed in the Pecatonica valley, near the Wisconsin line, and northward." Again several pages farther: (e) Deepening of the sea and the formation of the Buff or Pecatonica limestone, accompanied by a slight elevation in the north-eastern portion of the area, forming a small island."

If there is anything unscientific in the use of a geographical name as an application to a local phase of a formation commonly known as the "Buff limestone," whereas in this district it is the thinnest of four distinct "buff limestone" formations, is oftener found to be light gray and blue-gray than buff in color, and at the time of the preparation of the paper quoted from, did not seem to the writer to be capable of demonstration as an exact equivalent of a properly designated portion of the stratigraphic series of any other state: I repeat, if this is not in accordance with the customs of geological students in the Mississippi basin, I desire Dr. Sardeson to especially call my attention to it. The name was originally intended to be applied chiefly to the limited district then under investigation, and even then only until it would become apparent that some other designation of a proper nature for use in this district, has priority. I think it probable that under this rule, it will finally have to be known as the "Joachim limestone."

Freeport, Ill. O. H. HERSHEY.

PERSONAL AND SCIENTIFIC NEWS.

DR. PERSIFOR FRAZER, at the expressed wish of the late Dr. E. D. Cope, has assumed temporarily the managing editorship of the American Naturalist.

THE SANDSTONE DIKES OF THE UTE PASS, COLORADO. According to W. O. Crosby these dikes contain material derived largely or wholly, from the lower portion of the Potsdam sandstone of the region. They accompany the Ute Pass fault. Lithologically they are like that sandstone, and not like the later sandstones. The fault itself was probably not completed till post-Cretaceous time, but it may have been begun at a much earlier period. The Potsdam sand entered the collatteral fissures along the fault, because of its immediate superposition, and that relation also excluded the later sandstones. (Bul. Essex Inst., XXVII.)

NEW YORK ACADEMY OF SCIENCES. SECTION OF GEOLOGY, MAY 17TH, 1897. The first paper of the evening was by Mr. D. H. Newland, entitled "Occurrences and Origin of the Serpentines near New York."

Mr. Newland spoke of the occurrence of the serpentines in the vicinity of New York, and classified them according to origin into two probable divisions: one including those from New Rochelle and Hoboken, possibly derived from metamorphosed igneous rocks, and second, those from other localities more probably derived from some form of sedimentary rock.

The second paper of the evening was by Prof. J. F. Kemp, entitled "Notes on Butte, Montana, and its Ore Deposits."

Professor Kemp described the geological position of the copper and silver bearing ore rocks of Butte, and illustrated his talk with a number of lantern slides made from photographs in the region last summer. He spoke particularly of the geological succession exhibited in the relationship of two forms of granite, an earlier basic and a later acidic, cut by later rhyolite flows.

The third paper was by Prof. Kemp, entitled "Notes on the Geology of the Trail from Red Rock to and beyond Leesburg, Idaho."

This paper brought forth the first account known of the geology of about 100 miles of the trail mentioned, where the rocks are very varied in character, but mostly early Cambrian quartzites, together with many igneous rocks including Tertiary rhyolites. The ore producing region is found in the valleys where the gravels are washed in some places by hydraulic force and some gold gained therefrom.

The last paper of the evening was by Prof. C. A. Doremus, and was illustrated by a series of specimens recently received from France from M. Moissan, representing certain of the metals and carbides formed by the electric furnace. Some of these were very interesting geologically, because of their peculiar properties; particularly the carbonates of aluminum, calcium and cerium, which latter, when treated with water, produce all the gaseous series from marsh gas to the heavier petroleum products. The specimens exhibited are for final placement in the National Museum in Washington, D. C.

RICHARD E. DODGE, *Secretary.*

Respectfully
Your Obt Servt.
Charles T. Jackson

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THE

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CHARLES THOMAS JACKSON.

By J. B. Woodworth, Cambridge, Mass.

[Plate IV].

Charles Thomas Jackson, the first state geologist of Maine, Rhode Island, and New Hampshire, was born in Plymouth, Mass., June 21st 1805, the son of Charles Jackson, a merchant of that historic town by the sea, and Lucy Cotton, his wife.

To which of his parents, if to one more than to the other, the youthful Jackson owed his taste for scientific investigation and the grown man his genius for fruitful suggestion, it can not be stated with certainty; but it is believed that his ready memory was a gift from the Cottons.

Dr. Jackson's education and early training were of that liberalizing kind, gained in the attainment of medical lore, which has given to American science so many well-known names. Before the period of the professional scientific schools, an opening to the career of an educated naturalist and geologist was more largely through the study of medicine than by any other means. Medicine alone required at that time an acquaintance with laboratory methods in chemistry and an intimate knowledge of physiology or natural history. He began the study of medicine under the private tutorage of Drs. James Jackson and Walter Channing, who prepared him for entrance to the Harvard Medical school. He graduated as

doctor of medicine in the class of 1829, having received the Boylston prize for a dissertation on *Paruria Mellita.*

The young physician had already manifested his predilection for the inanimate world. It is stated that his interest in mineralogy was aroused, while staying in Lancaster, Mass., by finding the crystals of macle or chiastolite, which there abound in the glacial drift. Even before his graduation in medicine, he had in the summer of 1827 visited Nova Scotia with his friend Francis Alger, for the purpose of collecting minerals and making observations upon the geology of that province. He had also, partly for the benefit of his health, tramped through New York and New Jersey, with Baron Lederer, McClure, Say, Lesueur, and Troost, men whose acquaintance was apt to foster an interest in natural history. In the summer following his graduation, again accompanied by his friend Alger, Jackson went in a chartered vessel to Nova Scotia to continue the examination they had already begun. The results of these excursions formed his first published work.

Evidently with the intention of fitting himself for a high place in the profession for which his tutors had prepared him, Jackson, in the fall of 1829, went to Europe. He studied medicine in the University of France, attending lectures in the Ecole de Medicine, the College de France, and the scientific lectures of the Sorbonne as well as those on geology given by De Beaumont in the Ecole Royale des Mines. With this distinguished geologist he formed a friendship which lasted many years.

In 1831 Jackson walked through a large part of southern Europe, visiting the principal cities. His route took him through Switzerland, Piedmont, Lombardy, Tyrol, Bavaria, and Austria. In Vienna he performed autopsies with Drs. John Fergus of Scotland and Johannes Glaisner of Poland, on about two hundred patients who died of the cholera in the hospitals of that city. Thence he went to Trieste, Venice, Padua, Florence, Rome, and Naples, at which latter place he witnessed an eruption of Vesuvius. Going thence to Sicily, he ascended Etna, and then made a study of the Lipari islands. While in France he had not neglected to examine the volcanic district of Auvergne.

Dr. Jackson returned to America in the same ship with

Morse, the patentée of the magnetic telegraph, to whom there is some reason for believing Jackson gave important help in his experiments. Once again in Boston, Jackson began the practice of medicine, but finding his services in demand as a chemist and mineralogist, he gradually and not against his inclination, entered upon a career in these pursuits. He is afterward said to have expressed some regret that he spent so much time in the study of medicine.

The report on Nova Scotia had already given Dr. Jackson a name as a geologist and mineralogist. The movement for geological surveys which had led to good results in several of the sea-board states came in due time to arouse public interest in the little known region of Maine. The attention of Americans was also called to the importance of the frontier of this state by the claim of Great Britain to more than ten thousand square miles of that tract, the cause of a dispute which was finally settled by the treaty of Ashburton in 1842. It served at the time, probably, to stimulate the legislature of Massachusetts to co-operate with that of Maine in the survey of the public lands owned by the former state in the latter's territory. As a reminder of the former dependence of Maine upon the Bay State, we find duplicate reports of the survey, which Jackson was now called on to make, addressed to the governors of these two States.

Jackson spent the years 1837-1839 in this work. Without maps for most of the area, other than those made by himself, he traversed the country on lines intended to afford him an idea of the dominant features in the topography and geology. His reports set forth the places he visited, the sections he studied, and the names of the owners of the quarries and prospective mines whom he either discouraged or helped by his advice as the circumstances seemed to him to warrant. We find him making a careful study of the intersection of dikes to determine their relative ages, and entering upon generalizations with regard to the systems of intrusion. Everywhere he was on the outlook for some economic advantage which might accrue from his labors to the state, showing in this the peculiar trait of the American geologist under the employ of the public. Many details were recorded evidently for some future use, the author not disdaining to present them because

they did not lead up to some conclusion which it was his endeavor to maintain. "Let us then" he states, "carefully record all facts which we discover, and look confidently forward for some useful result."

It was not without some exhortation that the people of Maine were induced to continue the appropriations long enough to complete the cursory survey which Jackson planned to perform. Among other inducements, there were lectures on geology given before the legislature, of which reports appeared in the Kenebec Journal for 1838. In fact he appears to have experienced the usual tribulations meted out to a state geologist.

This state has been surveyed once since Jackson's time, but our knowledge of its geology is much less complete than is that of many thousand square miles of western wilderness.

Jackson had scarcely brought to a finish the survey of Maine before he was engaged by a committee appointed by the legislature of Rhode Island to undertake a geological and agricultural examination of that state. Two thousand dollars were appropriated for the purpose of defraying the costs. The contract was made in April, 1839, and on May 25th 1840, the manuscript of his report was tendered for publication. One thousand copies of the report were issued, being the first and last official account of the natural resources of the Island state.

From an examination of the report it appears that Jackson made long excursions out of Providence, visiting the principal towns and traversing the important rock groups so as to obtain general cross-sections of the area. The knowledge he thus gained of the geological distribution was fairly accurate. The Carboniferous rocks were separated from the crystalline and igneous rocks on the west and several minor subdivisions in these latter were introduced upon the map. It is only within recent years that geologists have recognized in the "primary" rocks of this report infolded patches of probably Carboniferous rocks.

Everywhere, Dr. Jackson came in contact with the people as was his wont in the examination of Maine. His report is a digest of his journeys with the elaborated results of his analyses of the minerals and soils of the state.

It was his method to give strictly scientific as distinguished from economic geology in the introduction of his reports. It will be worth our while to examine the introduction of the Rhode Island report somewhat at length, since the author has brought together there some of his concepts of the theory of geology.

It is clear from a perusal of this chapter that he was not an advocate of biological methods in geology. His predilection for chemistry and mineralogy manifestly made geology for him a mineralogical rather than a stratigraphical science, and the peculiarly crystalline character of the rocks of New England fostered this view of geology. "It must be evident," he states, "to any one conversant with modern geological works, that they are frequently very deficient in correct mineralogical descriptions of the rocks, while great stress is laid upon the accidental fossils, which they contain. Zoological and botanical characters are certainly of great value and importance, but they are not so decisive, respecting the age of a deposit, as the order of superposition of strata and the mineralogical composition of the rock itself." We shall see presently how he was misled by his reliance upon mineralogical characters and through the setting aside of the plain evidence of recognizable fossils. But we should judge him in this matter by the standard of "the forties" when the system of Werner had yet its advocates among the highest in the ranks of geological science.

It was in the case of the Rhode Island Carboniferous that Dr. Jackson gave way to the prevailing misconception of the meaning of metamorphism in its application to the problem of time. From the fossils contained in the coal measures, he inferred that the beds were of fresh-water origin, "either from lakes or from the estuary of some ancient river," an opinion which the writer believes abundantly confirmed by the most recent studies in this area. He recognized the likeness of the flora of these rocks to that of Pennsylvania and Nova Scotia and to the Carboniferous plants of New Brunswick, England and France, yet he rejected this evidence in fixing the age of the beds. "From the fossils alone," he writes, "a geologist would class the graywacke rocks of Rhode Island with the secondary formations, and make them identical with the coal

measures of England; but it will be difficult for any one who examines the order of superposition and the structure and composition of the rocks themselves to support such an opinion."

The Carboniferous rocks in the area in which he studied them present strong schistose and gneissoid phases, in places quite as well marked as in the region of his primary group. Crystals of garnet, andalusite, ottrelite, magnetite, and other metamorphic minerals, the most significant of which were observed by him, distinguished the matrix of these plant-bearing strata in a marked way from the coal fields of the standard sections. Because they were metamorphosed, he believed the rocks to be older than the Carboniferous of Europe. Had he seen the Massachusetts extension of these rocks, he would have found less evidence of this change.

But whatever bias Jackson may have displayed in crediting to mineralogic features values which he denied to biologic evidence as indices of relative age, he evinced a keen sense of the local geologic conditions. His understanding of the structure of the highly folded and metamorphosed rocks of the Carboniferous in Rhode Island has for half a century been little improved on by others.

He seems to have considered a numerical division of the groups of strata preferable to "any of those fanciful names" which took the place of Werner's Transition series. "It is evident," he adds to this expression of his choice, "that the names Cambrian and Silurian proposed for certain groups in England, will never be regarded in this country, as appropriate terms for our rocks." The old name was good enough for him, and so he wrote, "I therefore adhere to the name Transition as originally applied."

Though primarily an investigator, Jackson was at the same time and in his own way a teacher. The introductions to his reports are brief text-books of the science as he understood it. Even the pedagogical question of the order of presentation of geologic phenomena is debated with the reader, and in opposition to the then prevalent practice of English geologists of beginning with the phenomena of to-day and going downward in the rock history, he insists on the advantage of the ascending order, inasmuch as it sets forth the antecedent circum-

stances of each succeeding series of sediments and products of change.

Like Noah Webster, he made use of his wanderings in the rural districts to disseminate his views, and while one thus attempted a reform in the spelling of New England the other sought to improve the relations of men to the earth.

This report like the others from his pen was addressed to the people in language which they understood. His was not the task of the geologist detailed to report upon an uninhabited terrane, who writes for readers who know the area surveyed only through the medium of the printed page and the topographical map. His report could convey no description of the landscape to those mostly interested in it, for they knew it better even than he did. It was in the economical and agricultural side of his investigations that appreciation was to be bestowed on his work. The vast resources of the West were not yet made known. The soils and bog ores of New England still presented possibilities for agriculture and for industries which led the small landowner to entertain hopes which the succeeding years of national exploration and discovery have ever since proved false.

His Rhode Island report is embellished with some of the lore of the country folk. Just as Herodotus upon his entrance into Scythia was shown, among the curiosities of that country, the footprint of Hercules near the Tyras, so Jackson on going into Rhode Island had pointed out to him as the natural wonder of the land the Devil's foot-prints on the sandstone-gneiss ledges near Wickford, pits of differential weathering which remain to this day the common knowledge of the Rhode Island-born. Not to have incorporated this legend would have rendered the report of the state geologist incomplete.

In his geological work, Jackson saw everywhere the effects of igneous causes. He attributes the tilting of strata at Miantonomah hill near Newport to subterranean fire. He notes the crystals of magnetite in the paste of the conglomerates at Purgatory and regards their occurrence "as an absolute proof of the agency of fire, which has fused the cement and crystallized the oxide of iron." Once only do we find him tripping in his field observations in this survey. The wave-washed chasm in the conglomerate ledge at Purgatory, he makes the

site of a dike, "a small portion only remaining in the south end of the rent, to attest its former presence." The chasm, it has since been determined, is undoubtedly due to the removal of more finely jointed rock lying between master joints in the conglomerate.

Jackson even extended his views of igneous causes to the explanation of gneiss, thus anticipating the conclusion though not offerring the basis for it, which later investigators have worked out with the aid of the microscope. He regards gneiss in one stage of his work as the rapidly cooled crust of granite. Mica-schist he admits may be of metamorphic origin, that is in the Lyellian sense. In explaining the amphibolite of the pre-Cambrian area of Rhode Island, he states, "I am of the opinion that it derives its occasionally stratiform structure from an admixture of argillaceous slate rock through which it was elevated, or that the hornblende rock has partially fused and assimilated the superincumbent slates." But here he appears to have taken a hint from De la Beche, who held to a similar hypothesis.

In common with the elder Hitchcock, Jackson recognized in southern Rhode Island a group of clays and sands older than the very latest drift phenomena, but he included with these deposits the extensive sand-plains which occur about Providence. Under a mistaken notion as to their origin, these beds were referred to the Tertiary period. It is now known that the sands and clays pertain to a succession of glacial deposits, the Columbia and succeeding deposits of the Pleistocene.

In the matter of geological forces, he was not strictly a Strabonian. In speaking of the disintegration of rocks, he considers "the causes formerly in action vastly more energetic than they are now."

The Rhode Island report was not yet completed when Dr. Jackson was appointed state geologist of New Hampshire, Sept. 10th, 1839. By the law which authorized this appointment, provision was made for one assistant, "who shall be a skillful analytical and experimental chemist." To this office J. D. Whitney was appointed in December, 1840, and served in the laboratory that winter. Subsequently other assistants were employed. Although Jackson and Whitney parted com-

pany at about this period of their careers, we shall find them shortly engaged in succession in the same geological field: and however much they may have differed eventually in opinion, it is worthy of remark that Jackson chose Whitney to be his first official assistant in his geological surveys.

The four years from 1839 to 1843 were given to this survey, the final report appearing in 1844. Annual reports were made, the form of which is preserved in the final monograph. The title of this work bears the characteristic of the author's aim in the added words "with contributions towards the improvement of agriculture and metallurgy." The introductory chapter is, like that of the Rhode Island report, interesting reading to the student of American geology. In it Jackson frees himself from the details of minerals and rocks as such and the localities in which they occur, in order to discourse upon the principles of geology, its nomenclature, and upon the relation of the rocks of New Hampshire to the standards of the European column.

Neither at this early period nor later in his writings does he appear to have become involved in the intricacies, either pro or con, of the Taconic question. This is probably for the geographic reason that his field of investigation lay mainly to the eastward of the area studied by Ebenezer Emmons. Yet Emmons found his Taconic system in Rhode Island and also in Maine. From the latter state, he describes *Nereites jacksoni*, "a name," he states, "conferred from respect to my esteemed friend, Dr. C. T. Jackson." It appears also that Jackson in later years, as at the time his field work was done, was not interested in questions of chronology.

With singular conservatism, he retains in bold type in the New Hampshire report, the Wernerian "Transition" group as the best term in his opinion for rocks denominated Cambrian and Silurian by Sedgwick and Murchison. Yet there is nothing of intolerance or a wish to suppress their views. He gives their names place in the text and protests against their use rather than refuses to employ them. He strengthens his arguments advanced in the Rhode Island report, and remarks "that we must regard these terms as merely provisional; for we cannot discover any relationship between rocks formed ages anterior to the creation of man, and the tribes who in com-

paratively modern times, happened to dwell upon the surface; nor can it fail to strike one as absurd, that the rocks forming a large portion of this continent and that of northern Europe should be called after the former inhabitants of a small tract of country in England and Wales. We object," he adds, "to the introduction of mere local names into general geology, and would prefer a numerical arrangement, when it can be generally agreed upon by the scientific men of Europe and America. It will be better to adhere to the old groups, primary, transition, secondary and tertiary, since these are universally understood and convey with sufficient accuracy the ideas of their arrangement, while each group may be subdivided at pleasure, into as many strata as contain peculiar fossils."

With this commendable project, not however without a leaning towards the Wernerian mineralogical school, Jackson was throughout consistent.

In not one of the three New England states on which he by priority of his surveys had the privilege of placing rock names of his own choosing did he leave a local designation or fasten a system of stratigraphy differing from that previously known. His reason for not applying rock names seems to have depended more upon his ideal of a geological nomenclature than upon doubts in regard to the identity of important groups. It is somewhat remarkable to note him working in this manner, refraining at every step from a practice, which his contemporaries west and south of the Hudson were following, mainly with success in New York state. But the conditions differed vastly on the opposite sides of this river. There was little incentive in Jackson's environment to make out a time scale for the rocks. The gnarled and topsy-turvy stratigraphy of eastern Massachusetts may afford a birth-place for a James Hall, but it will not rear him. He must be transplanted while young and impressionable to a region of more orderly rocks than that of Hingham. Jackson's mind responded to a terrane in which chemical, mineralogical, and structural questions predominate over the clearer facts of vertical succession, as presented west of the Taconic range.

In view of the complexity of New England geology and of the time at his disposal for the elucidation of the intricate

problems of geological succession which have since come to light in this field, it must be admitted that the course pursued by Dr. Jackson in these state surveys was on the whole wisely chosen. To have attempted to make out a standard section with local names in accordance with the plan pursued in the neighboring states of New York and Pennsylvania at this time or a little later would have proved disastrous. It was in a later period and in other minds that there grew up in this region, while the schistose structure was still regarded as akin to stratification, a classification of rocks whose ruins have hardly yet been cleared away in the search for the true order of events in this field. Jackson in New Hampshire as in the other states studied by him was seemingly content with setting forth the economic facts of his discoveries, and on the whole the task of the modern geologist in New England is made the easier by Jackson having denied himself the Edenic privilege of giving names to things. The right man in the right place and at the right time may bring out a standard classification for a state, a country, a continent, or for the world. But an attempted system of this character, failing of adoption, locks up voluminous and often valuable reports under the rusty keys of a cumbersome and unknown terminology.

Though a laboratory habitué, Jackson was particularly at this period an active field worker, and allowed no trifling barrier to stand in the way of his field inquiries. It was in the progress of the New Hampshire survey that he dove to the bottom of a pond to find beneath the mud a deposit of iron ore whose presence was suspected there. This and other incidents of travel and simple adventure are written down in his report as interlarding to the technical results of his researches.

In 1847, Jackson was appointed U. S. geologist to report upon the public lands in the Lake Superior region. After spending two field seasons in this work, he resigned, for reasons best known to himself and the then unfriendly authorities in Washington. In the company of Hon. David Henshaw, ex-secretary of the Navy, he had previously made a visit to this district while employed in the New Hampshire survey and found copper. He did his share in opening up this great copper region. There was incredulity in the East in regard to this

store of native copper. In a letter to the editor of Silliman's Journal, after noting a fifty-ton lump of copper, Jackson adds, "Those who were surprised that I recommended working mines for native copper, should come and see and they would believe."

Important as were the economic results attained in this field by his labors, his views of the geological structure and of the succession, if properly understood at the present day, are not in accord with the most recent results obtained in that field. Foster and Whitney succeeded to the work in the copper region. They set aside the theoretical work of Jackson, and in turn their views have been displaced by later investigators. Such has been the history of progress in other fields.

In the reaction from the doctrine of Werner concerning the basaltic rocks, the geologists of the middle years of the century just closing were largely blind to the evidence of igneous rocks which were not intruded but spilled out over the surface in the form of contemporary sheets. The enormous lava flows of the Keweenaw peninsula were regarded by Jackson as intrusive rocks capable of elevating the sandstones with which they are associated. It is only within recent years that the essential flow character of the trap masses in the upper portion of the Connecticut valley has been recognized. If Jackson made a mistake in this matter, he has had able company in the years that have passed. The age of the red sandstones on the north side of the peninsula still depends upon local evidence of unconformity. Jackson seems to have considered the rocks of Triassic age, agreeing with Marcou; later he expressed some doubt. Now the rocks are placed by the U. S. geological survey between the lower Cambrian and the Huronian. But Jackson in later years thought that our red sandstones might be of very different ages. It is not probable that he attached much importance to the question of age of the Lake Superior sandstones. There, as in New England, it was the economic geology which interested him mostly.

Before passing from this phase of Dr. Jackson's work, it should be stated that he was appointed one of the state geologists of New York by governor Marcy, but resigned. He had also been called upon in planning the work of that survey.

Jackson's work as a state geologist came to an end with the first half of the century. Thence forward we find no abate-

ment of his interest in the science, though his work is more limited in its scope, being mainly mineralogical and chemical. His work in mineralogy was of a character to link his name in one way or another with several minerals. Masonite which he named and described in the Rhode Island report is regarded by Dana as an impure substance and is referred to chlorotoid. It was rather his own fault than professor Whitney's that Jackson's name is not borne by one of the Lake Superior minerals. Jacksonite was proposed by Whitney for a supposed hydrous prehnite from Keweenaw Pt. and Isle Royale. Dr. Jackson. with his accustomed method of procedure in such cases subjected this mineral to analysis and found that it was lacking in the requirement of water, a conclusion with which Dana concurred.

Jackson appears to have been the first to observe the occurrence of tellurium and silenium in America. He was also the first to report amazon-stone (1859). His geological inquiries led him into the field of mineral genesis, and we find him boldly demanding a deepseated origin for substances then thought by many to be due to the selective action of organic life. Phosphate of lime, he argued, is not necessarily of organic origin, since it is found in igneous dikes. For the same reason he concludes that phosphorus is an element in the interior of the globe.

Perhaps his most important work in mineralogy was economical in its character. The emery mines of Massachusetts remain a monument, hollow and inverted, it is true, to his acumen in this field of research. As he himself states, this locality was found by Dr. H. S. Sears, but it was Jackson's part to develop the real value of the locality. From the minerals already known there, he inferred the existence of emery and found it. Up to that time, a London banking house controlled the only workable deposits of this variety of corundum, those of the Grecian archipelago.

His exploitation of the lean ore bands of New England deserved better success to himself and to land owners than have accrued in the years since traces of metals were discovered in this area. Numerous were the rumored occurrences of tin, gold, and other useful ores which he diligently ran down and investigated in hopes of their proving of industrial impor-

tance. Few of these finds proved little more than a stimulus for further search.

Dr. Jackson was a fairly good naturalist of the old school. Neither zoölogist nor botanist, he was an observer of animals and plants in life, to say nothing of his stewing and cooking them in his beakers and condensers after they were dead for the sake of the information they would then afford. Witness his observations upon the bream, the ale-wife, the sand-sharks of Nantucket, the Spongilla in the Brookline reservoir, the pink water-lily, the studies of the habits of the beaver, and the notes on the giant Sequoias of the Sierras. But he was particularly acute in the detection of mineral matter, largely because he was forever analyzing. He found traces of manganese in the waters of the middle of lake Superior; he found fluorine in the bony scales of certain fishes; and before the discoveries of Berzelius, although he did not name it, he detected humic acid in the soils of Rhode Island. Sometimes his discoveries were of more than scientific interest, as was that of emery just described in the still worked mines of Chester, Mass.

Almost disdaining to trust to fossils in the correlation of the stratified rocks, particularly where metamorphism was present, he was a constant collector of fossil fishes and other forms met with in his field work. He even described several species of Palæoniscus. Some of the Deep River fossils described by Ebenezer Emmons, in his North Carolina report were collected by Jackson.

Jackson's scientific life for over a quarter of a century following the period of his active duties as a state geologist, is an integral part of the history of the Boston Society of Natural History, and the records of this institution afford a valuable commentary on his ready information in various departments of natural science. Elected vice-president of the society in 1847, and declining on account of impaired health to be made president in 1870, he was a faithful attendant on the meetings of this organization during this long period; and was quite as often in the president's chair, as was the duly elected officer to that post. Here Jackson brought the discoveries of his field and laboratory work and the ripened conclusions of his earlier geological inquiries, finding among his

hearers Louis Agassiz, Jeffries Wyman, T. T. Bouvé, T. Sterry Hunt, and numerous younger men, among whom the names of LeConte, Shaler, Niles, Hyatt, and others are recorded in the reports of these meetings.

On these ocassions, Dr. Jackson was ever ready with questions and remarks elicited by the papers of others, when his own abundant labors were not the subject of discussion. The store of his ready information and the range of his interests and investigations are shown by the list of his remarks published in the biographical notes appended to this paper.

To the geologist, the records of these gatherings afford a clearer insight into Dr. Jackson's views on many questions than do his special works upon areal geology. His idea of the origin of elongated pebbles in conglomerates through the shaping action of waves on a beach, his general denial of belief in the glacial theory of professor Agassiz, his disavowal of the derivation of igneous rocks through the fusion of sediments in the ultra-stages of metamorphism, are conclusions which find a place in these proceedings along with the propositions and rejoinders of his able associates. From time to time he made more important contributions to the publications of the society.

Dr. Jackson did not always push his theories of geological phenomena to the fullness of conclusion and statement which would enable us at the present day fully to understand them. He had too many irons in the fire to do as he would with all of them. Here and there, as in the chance remarks of many of the older geologists, we find the germs of theories which have since been prominently advocated. In discussing the joints of the Roxbury conglomerates, near Boston, he anticipates Crosby's elaborated thesis, by suggesting that earthquake shocks might have been the cause of the phenomena. He pointed out a criterion for distinguishing ice-borne from water-transported detritus, the first remaining coarse up to the limit of distribution, the second decreasing in size of the particles as the distance from the original source increased. This point has since been made out in the study of glacial phenomena in the Alps.

Although an advocate of deformation of the crust by the agency of internal heat, he put forth the idea which in its

thoroughly qualified form we know as the doctrine of isostasy. He recognized the effect of the shifting of load through denudation. He supposed that when the difference of level had become sufficiently altered to be adequate to overcome the resistance of the earth's crust a paroxysmal elevation might take place, with all the phenomena of an earthquake, as happened in China in 1834.

Occasion has already been found for referring to his methods of correlating strata. In all this and what follows, we must remember that immense strides have been made in the understanding of this problem within the lifetime of the younger geologists. Jackson simply reflected the methods of others when he was led by a question to state that he "had sought carefully for impressions of rain drops" in the Lake Superior sandstones, "for the purpose of identifying the age with that of the Connecticut River sandstone, but in vain."

Metamorphism, if we may accept most of the references he makes to the subject as embodying his views, is the result of igneous action. Yet he thinks hot water under ocean pressure a satisfactory explanation of the making of the anthracite of Pennsylvania. His explanation of gneiss has already been referred to. He did not regard water of crystallization in igneous rocks as proof of their original sedimentary condition. Fragments of slates in the granites of the White Mountains, he thought to be an occurrence irreconcilable with the view that the igneous rock was melted down sandstone and slate. His conception of igneous rocks was that which is held by the modern petrographer. Jackson believed thoroughly in the intrusive origin of these rocks. He saw in them no signs of a previous clastic texture or stratified condition.

Jackson's laboratory was a well known place. It was one of the first if not the first of chemical laboratories in this country to receive students. His reverend friend, Dr. Bartol, who was a frequent visitor there, tells an anecdote of the place. "One day," so Jackson told him, "a countryman came in with a handkerchief full of those yellow blocks called iron pyrites, saying he had found a gold mine on his farm, and would not take no for an answer. The patient chemist held some of the little cubes in his shovel over a blazing fire till

the sulphur was disengaged, and then, putting the smoking mass under the farmer's nose, asked him what that smelt of. '*Hell*,' was the somewhat hasty reply."

Jackson was a genius. He had the inventive faculty; the habit of incessant investigation; the capacity of getting tangible, fruitful results; and the ability to suggest successful expedients to others. Geologists think of him as a geologist. He had other callings. At the end of his manual of Etherization of 1861, we find his card.

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Be Beaumont* wrote of him in 1852 as "bien connu par ses travaux sur la geologie de plusieurs parties de l'Amerique du nord et plus celebre encore par son important decouverte de l'Etherization." In the public garden at Boston is a statue erected to the discoverer of the use of ether as an anæsthetic in surgery; but no name is inscribed thereon. That blank marble tells nothing of the mental anguish and of the closing days of the rival claimants for the honor which the distinguished author of the Pentagonal Network unqualifiedly gives to his friend Jackson. The arguments of the famous "ether controversy" are not germane to this sketch of Jackson, the geologist. Jackson, it should be stated, was a claimant for priority of the discovery. The French academy of Sciences awarded him the honor. There were other claimants, Morton and Wells. It is stated that Dr. C. W. Long, a physician in Georgia, performed surgical operations by the use of sulphuric ether four years before it was employed in Boston. Some of the writings on this subject of dispute are given in the appendix.

Dr. Jackson occasionally gave lectures on geology, as at Lexington in 1855. These were generally delivered from carefully prepared manuscripts. From the manuscript of one of these lectures, we learn his views in regard to design in the

* Notice sur les Systemes de Montagnes, p. 702.

world. "From an attentive study of the structure of the earth," he states, "we cannot fail to discover that it has been made after a preconceived plan, and that the highest wisdom is manifested in the adaptation of the world to the uses of man."

Scientific work mainly occupied the attention of Dr. Jackson until 1873. Then his active mind gave way. The recovery for which his friends hoped never came; and on the 28th of August, 1880, after seven years of suffering, Dr. Jackson died in a department of the Massachusetts General Hospital.

Dr. Jackson is described by those who knew him as an enthusiastic person, a ready conversationalist, even eloquent in his speech, and fond of telling stories. His friend, Dr. C. A. Bartol, whose church Jackson attended, says of him that he "was simple as a child and veracious like the sun." The controversies in which he became involved brought out his fighting qualities. "He was a man," states Dr. Bartol, "whose self-respect did not allow him to waive his own claim, and of course his attitude could not please those who were inclined to reduce them to the lowest point."

He is remembered as a rather large man, who might be seen in his laboratory absorbed in work and unmindful of his personal appearance. The portrait reproduced in this sketch represents him as a young man. In a photograph taken later in life, the head appears more massive, the shoulders squarer; the beard covers more of the cheeks; the physiognomy exhibits more firmness and something of complacency, for despite disappointments, Dr. Jackson received recognition and honors for the share he had in the use of anæsthetics in surgery.

Dr. Jackson was a member of numerous learned and scientific societies in his own country and abroad. The plain title page of his Rhode Island report makes known that the author is a Fellow of the American Academy; Member Geol. Soc., France; Memb. of Imperial Min. Soc., St Petersburg; Memb. Boston Society Nat. Hist.; Cor. Memb. Acad. Nat. Sci., Phil.; Lyseum Nat. Hist., N. Y.; Albany Inst.; Nat. Hist. Soc., Montreal; Providence Franklin Soc.; Hon. Memb. Maine Inst. Nat. Sci. He was also a member of Amer. Assoc. Geol. and Nat., of which organization he was chairman in 1845-46. Later he became Chevalier de la Legion d'Honneur; Caviliere dell'Or-

dine dei S. S. Maurizio e Lazzaro; Ritter des Rothen Adler; Knight of the Turkish Order of the Mejidich. Numerous other scientific and medical societies sought to honor him with membership in their organizations.

Dr. Jackson was married to Miss Susan Bridge of Charlestown, Mass., on the 27th of February, 1834. Three sons, two daughters and his wife survive him.

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On the Tertiary of Maine, p. 213. Deposits from Lubec to Portland, now known to be Pleistocene.

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Discovery of Tellurium in Virginia, p. 88. From auriferous vein in Whitehall, near Fredericksburg.

A new method of extracting pure gold from alloys and from ores, p. 187. Oxalic acid and carbonate of potash method. Also in Edinb. New Phil. Jour., XLVI, 1849, 164-166.

Proc. Boston Soc. Nat. Hist., iii, 1851.

Remarks on Prof. Hare's experiments on fire-flies, p. 8.

Remarks on metamorphosed rocks, pp. 19-20. Did not regard water in minerals as proof that they were not of igneous origin.

Observations upon the drift scratches on the Roxbury conglomerate, p. 28. Fracture of the pebbles runs N. 30 degrees E.

Notes on the solubility of gun cotton, p. 30.

Remarks on a zeolite mineral from lake Superior, pp. 76-77.

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Amer. Jour. Sci., vii, 1849.

Copper of the lake Superior region. (A letter to the editor), pp. 286-287. Notes a 50-ton lump of copper. "Those who were surprised that I recommended working mines for native copper should come and see and they would believe."

Proc. Boston Soc. Nat. Hist., iii, 1851.

Observations on an oyster bank near Newcastle, Me., p. 88.

Remarks on the relative age of the American continent, p. 88. Considered oldest on account of the granite showing marks of greater age.

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Remarks on the structure of ice and glaciers, pp. 124, 126.

Remarks on fissures in puddingstone of Roxbury, p. 127. If due to contraction, pebbles should drop out. Suggested that an earthquake shock might have been the cause of the phenomenon. Considered the puddingstone anterior to the coal.

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The mirage of lake Superior of the months of July and August, 1847, p. 169.

Remarks on a calamite from Bridgewater, Mass., p. 223.

Remarks on salt and carbonate of soda from the west, pp. 223-224.

Analysis of water from a hot spring in the region of the Great Salt lake, p. 224. Reprinted in Amer. Jour. Sci., x, 1850, p. 134.

Remarks on the plumbaginous mica slates of Vermont, p. 224.

Remarks on Foster and Hill's opinion as to the age of the lake Superior sandstone, p. 228.

Eulogium upon Dr. Martin Gray; p. 231. By title only.

Analyses of three samples of white cast iron, pp. 232-235.

Remarks on the desirability of examining a sandstone in the quarry, p. 241. Best test for resistance to weather.

Analysis and description of Vermiculite from Millbury, Mass., pp. 243-245. Analysis by Richard Crosseley.

On a mineral named Jacksonite, pp. 247-248. "The purport of the paper was to show that Jacksonite is not a new mineral.... Mr. Whitney being present, stated that he had full confidence in the results of his own examination of the mineral in question, and he must still consider it a new mineral." J. D. Dana accepts Jackson's criticism.

Remarks on Prof. Rogers' theory to account for the origin of the green sand of New Jersey, p. 249. "The process would be similar to that of the drying of French green."

Suggestion that bog iron ore combined with lime would be of agricultural use, p. 257.

Remarks on an Aztec skull from Mexico, p. 260.

Analyses of Algerite by Mr. Crosseley, pp. 278-279.

Description and analysis of asphaltum recently discovered in New Brunswick, pp. 279-280. Asphaltum from Dorchester, N. B.

Remarks on artificial minerals from slags of an iron furnace in Pennsylvania, p. 282. Also in Proc. Amer. Assoc. Adv. Sci.

Remarks on the change of level of lake Superior, p. 292.

Description and analysis of Tellurium ore from Whitehall, Va., pp. 297-299. Also in Proc. Amer. Assoc. Adv. Sci.

Observations upon the solution of lead and tin by Cochituate water. p. 299.

Remarks on iron ore from the Allegheny river in Penn., p. 319.

Remarks on the effect of concentrated sulphuric acid on minute algæ and spores, p. 320.

Remarks on tertiary deposits in Duxbury, Mass., pp. 323-324, p. 329.

A shark's tooth, a cetacean vertebra, lignite and a cast of a Tellina, in Marshfield in a clay marl over a green sand, 30 feet from the surface. Also Proc. Amer. Assoc. Adv. Sci., IV, 1851, p. 251.

Remarks on pot-holes in N. H. and N. J., p. 324. Also Proc. Amer. Assoc. Adv. Sci., IV, 188-190.

Some observations on the age of the sandstones of the United States, pp. 335-336.

On crystals of Allanite, containing protoxide of cereum in Labrador feldspar at Franklin, N. J., p. 326. Also Proc. Amer. Assoc. Adv. Sci., IV, 1851, 324.

Appointed a committee with Dr. N. B. Shurtleff and Dr. Cabot, Jr., to memorialize Congress on the subject of attaching a corps of naturalists to the Mexican Boundary Commission, p. 326, 330.

Observations upon the age of the sandstones of the U. S., pp. 335-336; 337-339. Thinks age of all our red sandstones questionable.

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Amer. Jour. Sci., xi.

Geological report on the lake Superior copper region, pp. 147-148. Also Karsten Archiv., xxv, 1853, 656-667. A notice.

Proc. Boston Soc. Nat. Hist., iv, 1854.

Description and analyses of pitch stone from Isle Royale, lake Superior, pp. 47-49. He argues that phosphate of lime is not necessarily of organic origin, since it occurs in igneous rocks.

Remarks on "Asphaltic coal" from New Brunswick, pp. 55-56. Also exhibits sticks of phosphorus made from phosphate of lime from New Jersey.

On coal and ganoid fishes from the head of the bay of Fundy, pp. 64-65. Also ibid., pp. 73-74, together with observations on Sigillaria.

Remarks on the insoluble portion of the coal from Hillsboro, N. B., p. 81.

Proc. Amer. Assoc. Adv. Sci, 4th meeting, New Haven, 1850. 1851.

On ancient pot-holes in rocks, pp. 188-190.

On Tertiary fossils at Marshfield, Mass, p. 251. Paper not published. See Proc. Boston Soc., N. H., III, 323.

Description and analysis of Allanite from Franklin, N. J., pp. 323-324.

Description of Bismuthic Tellurium or Tetradymite from the gold mine of Whitehall, Virginia, with an analysis of the mineral, and its relations to the gold associated with it, pp. 324-325.

On the manufacture of zinc and zinc white, pp. 335-337. Description of works at Franklin, N. J., and of process and mills at Newark, N. J.

Analysis of red marl of Springfield, Mass., pp. 337-338. An igneous contact product. Showed wood painted with it.

Remarks on the limits of barrenness and fertility in soils, p. 338.

Artificial minerals from an iron furnace in Easton, Pa., pp. 384-385. Gives analysis.

Zircon, sodalite, cancrinite, etc., from Litchfield, Me., pp. 385-386. By title only.

Report on the Albert coal mine, containing an account of the situation and geological relations of the rocks, including and accompanying the coal. New York, 1851, pp. 58. (With reports by Percival and Aug. H. Hayes.) Maps and plates referred to but not accompanying copy in Library museum, Comp. Zool., Cambridge, Mass. Reviewed in Amer. Jour. Sci., XIII, 1852, pp. 276-277. Darton lists a Boston edition; not seen.

Anniversary address before the American Institute, 16th Oct., 1851. New York, 1851, pp. 23.

1852.

Proc. Boston Soc. Nat. Hist., iv, 1854.

Remarks on raindrop imprints and allied phenomena, pp. 131-132. "Has sought carefully for impressions of rain drops (in the lake Superior sandstones) for the purpose of identifying the age with that of the Connecticut river sandstone, but in vain."

Description of five new species of fossil fish and notices of fossil plants from the shales of the coal formation at Hillsboro, N. B., pp. 138-143. Palæoniscus alberti, P. brownii, P. cairnsii, P. sp.

Remarks on a daguerreotype of a fossil fish, pp. 151-152.

Remarks on the characters of coprolites, p. 169.

Observations on a wavy sandstone in the shales at Hillsboro, N. B., p. 170.

Remarks on the "sienite" of Nahant, *loc. cit.*

Remarks on tracing the source of sediments. p. 179. Case on Peticodiac river in N. B. Fineness increasing in proportion to the distance from probable source indicates the action of water rather than ice in their distribution.

Observations on the relation of Stigmaria to Sigillaria, pp. 179-180. Doubtful as to their identity.

On an extensive deposit of marine shells near Portland, pp. 181-182.

Remarks on relative amount of oxygen in moist and dry air, p. 186.

Observations on the effect of sugar and raisins upon explorers, p. 187. "When suffering greatly from cold....eating a few raisins was sufficient to impart a glow to the whole system."

Observations upon a vein of anthracite at Vinal Haven, Me., and upon frictional electricity in cannel coal, p. 188.

Account of the process of etherization as performed on a puma for the purpose of cutting off its claws, p. 232. By title only.

Analysis of the body and scales of a species of Palæoniscus from the Albert coal mine in Hillsborough, N. B., p. 239.

Observations upon the Bream (Pomotis vulgaris), in a pond near Plymouth, Mass., p. 241.

Proc. Amer. Acad. Arts and Sci., ii, 1852.

On manganese in the water of streams, p. 111. M. in the middle of lake Superior and in the blood.

Report of a committee on coast marks, pp. 221-223. Proposal to have U. S. Coast Survey undertake observations.

Remarks on apatite from Hurdstown, N. J., pp. 241-243.

Temperature at which charcoal takes fire, p. 256.

Analysis of crystal of phosphate of lime from Hurdstown, N. J., p. 261.

Remarks on Prof. Horsford's explanation of an explosion of burning fluid, pp. 316-317.

On the use of alcohol as important to agriculture, pp. 322-323.

Observations on tellurium in gold ore from Frederick, Va., p. 2.

Bull. Geol. Soc. de France, x, 1852.

Sur le terrain houiller d'Hillsboro (Nouveau Brunswick), pp. 33-39. Gives two sections. In a lawsuit, court adopted J.'s decision concerning "asphalt."

Review of (his) reports on the coal of the Albert Coal Mining Co., Hillsboro, N. B. New York, 1852, 8to, pp. 40. Library Boston Society Nat. Hist.

Reports of the New Jersey Zinc company, 1852. New York, 1852, pp. 32. Geological report by Dr. C. T. Jackson, pp. 10-15, pls. 1 and 2, mentioned, but not in Harvard University copy.

Report on the trade and commerce of the British North American colonies, and upon the trade of the Great Lakes and rivers, by I. D. Andrews. 32d Cong., 1st sess., Senate, Ex. Doc. No. 112, xi, 1852. (Not seen.) Cited by N. H. Darton.

Boston Medical and Surgical Journal, xlvii, 1852.

Poisonous chloroform, pp. 117-120.

1853.

Proc. Boston Soc. Nat. Hist., iv, 1854.

Observations upon the Eupychroite from lake Champlain, pp. 259-260. Trap mineral; concludes that phosphorus is an element in the interior of the globe. Further remarks on pp. 264-265, 259-260.

Remarks on compressed crystals of tourmaline, p. 265. Also account of zinc mines, Sussex county, N. J. (Title.)

Account of the process of extracting iron from the ore called Franklinite in Sussex county, N. J., pp. 295-296.

Report on the coal lands of Egypt, Belmont, Evans, Palmer and Wilcox plantations of Deep River, N. C., 8vo pamphlet. New York, 1853. Cited in Proc. Boston Soc. Nat. Hist., iv, 1854, p. 403.

Bull. Geol. Soc. de France, (II) x, 1853.

Sur les mines de cuivre et de houille de la Caroline du Nord., pp. 505-506. Extrait d'une lettre a M. Delesse.

Report on the copper mine of the North Carolina Copper company, 1853, pp. 8.

Ueber den Metall führenden Distrikt, am Obern See in Staate Michigan. Karsten's Archiv., xxv, 1853, pp. 656-667.

Report vindicating the rights of C. T. Jackson to the discovery of the anæsthetic effects of ether vapor. (Appended to Morton, W. F. G. statement, etc., 1853, pp. 493-566.) (Not seen.)

1854.

Proc. Boston Soc. Nat. Hist., iv, 1854.

Remarks on the claim that Lord Sterling opened the "Sterling" mines in New Jersey, p. 308.

Remarks on crystalline limestones, pp. 308-309.

Remarks on the Wilkesbarre coal field, p. 328.

Remarks on the geology of portions of North Carolina, Georgia and Tennessee, pp. 397-401.

Ibid., v, 1856.

On the relations of Green river to the Mammoth cave in Kentucky, p. 57.

On gold, silver, lead and copper, at Bridgewater, Vt., p. 62. Also notes on native iron from Sonora, Mexico.

On fossiliferous erratic blocks at Mt. Katahdin, Me., and on the south shore of lake Superior, p. 85.

Chemical researches on the composition of the scales of the gar-pikes, p. 92. Contain fluorine.

Catalogue of rocks, minerals, and ores collected during the years 1847 and 1848 on the geological Survey of the United States mineral lands in Michigan. Smithsonian report for 1854, pp. 338-367, 1855.

1855.

Proc. Boston Soc. Nat. Hist., v, 1856.

Analysis of Allophane from Tennessee, p. 120.

Remarks on tides in lavas of volcanoes, pp. 139, 142.

Remarks on effects of gradual transportation of earthy matters from elevated lands, p. 142. "When the difference of level had been sufficiently altered to be adequate to overcome the resistance of the earth's crust a paroxysmal elevation might take place with all the phenomena of an earthquake, as happened in Chili in 1834."

Remarks on the views of Dr. A. A. Hayes and Dr. John Bacon concerning the cause of the taste and odor of Cochituate water, pp. 161-164. Hayes' rejoinder, pp. 169-175; Jackson's reply, pp. 175-176. (About this time, report of the Cochituate Water Board, by Horsford and Jackson. Not seen.)

Remarks on the age of the red sandstones from Connecticut, p. 186.

On the oxides of cerium, didymium, and lanthanium, in a large crystal, p. 189.

On raindrop impressions in foot-prints, p. 189.

Remarks on the qualifications of Mr. Marcou in relation to his geological discoveries in the Rocky mountains, p. 191.

Translation (?) of extracts from a letter of M. Elie de Beaumont, dated Paris, March 23d, 1855, p. 204-205.

On anthracite coal from Japan, p. 207. Coal used by U. S. S. Mississippi on return voyage.

Remarks on local characters of minerals, and on their association, pp. 225-226. Also described a fossil skeleton of a large cetacean from Maine. (Not printed.)

An account of some researches into the composition and manner of formation of different kinds of steel, p. 232-233.

Presentation of fossil shells from tertiary strata of Wilmington, N. C., p. 233.

Geology of parts of New Brunswick and Nova Scotia, pp. 242-250.

1856.

Proc. Boston Soc. Nat. Hist., v, 1856.

Observations upon a pumiceous substance reported to have been found floating around a point of explosion and ebullition in the water of the Ohio river, p. 290.

Exhibition of a vial of blood taken from the heart of a woman who died from the effects of chloroform, inhaled at a dentist's office, and remarks on the same, pp. 307-309.

Remarks on Gigandibus caudatus, Hitchcock, p. 309.

Action upon the death of Dr. T. W. Harris, p. 313.

On the chemical analysis and comparison of serpentine marbles known under the name of Verd antique, pp. 314-319.

Exhibition of a new water filter, with remarks on cyclopean animalcules caught therein, p. 333.

Explanation of the formation of stalactites, p. 335. Cites stalactites in the grotto at Carneal, near Trieste.

Remarks on analyses of serpentine, pp. 341-342.

Remarks on the replacement of human bones by phosphorus, pp. 346-348.

Account of the method employed in the extraction of oil from Menhaden and of converting the residual matter into a substitute for guano, pp. 355-356.

Observations on Hawaiian lavas, p. 356.

Remarks on the Philosophical Society of Victoria, p. 357.

Exhibition of a specimen of aluminum manufactured into a thimble, p. 357.

Ibid.. vi, 1859.

Geology of Alger's Beryl hill, in Grafton, N. H., p. 23.

Account of the trap dykes of Cohasset and other places, pp. 23-24.

On the coal formation of Deep River, N. C., pp. 30-32, 33. Visited in May, 1856.

Chemical analysis of a variety of Agalmatolite, pp. 32-33. Rock found on border of Deep river coal field, N. C.

Reported remarks on the trilobites from Braintree, Mass, pp. 42-44.

Geological report of lands belonging to the Ridgway company in Ely county, Penn. Philadelphia, 1856, 8vo, pp. 19. Copy in Harvard College library.

Report of the Ridgway Farm and Land company, together with the geological report of Dr. C. T. Jackson. Philadelphia, 1856, pp. 29. Copy in Mrs. Jackson's possession.

Boston Medical and Surgical Journal, liv, 1856.

Chloroform and formic acid, p. 146.

Formic acid in the blood, pp. 242-244.

1857.

Proc. Boston Soc. Nat. Hist., vi, 1859.

On supposed replacement of human bones by phosphorus, p. 57.

On mineral concretions of hydrated black-oxide of manganese imbedding sand, p. 91. From Tuftonboro, N. H.

On hematite iron ore belonging to the Brandon Iron and Car Wheel Co., p. 131.

On landslides on the Presumpscot river, in Westbrook, Me., pp. 133-134. Also remarks on concretions.

On Cyathophyllum in the drift of lake Superior, p. 139.

Exhibition of articles made of aluminum, p. 139.

On the alloys of aluminum with silver, copper, and zinc, p. 159-160.

On the cements of sandstones and conglomerates, pp. 168-169.

Remarks on crystallized sugar from Chinese sugar cane raised in Massachusetts, p. 170.

An account of the copper mine so-called at Elk Run, Fauquier county, Va., p. 183. In trap dikes coming through triassic sandstone.

On superposition of the sandstones of the Connecticut river at Northfield, Mass., p. 184. Palæozoic wanting.

On crystals of cane sugar, p. 203.

Maryland marbles and iron ores, pp. 243-245.

On carbonate of lime in sea-water from coral regions, pp. 257-258.

Observations on the shells of Alasmodonta arcuata from Maine, pp. 258-259.

An account of the sand sharks caught near Nantucket, p. 259.

Presentation of a brick from Manomet, near Sandwich, p. 260.

Remarks on vibrations noticed at the dam at Nashua, N. H., p. 267.

Observations on the occurrence of a Spongilla at the Brookline reservoir gates, p. 268.

Remarks on the presentation of a pink water lily (Nymphia odorata) from a pond in Yarmouth, p. 268.

Remarks on crystals of sugar from Sorgum saccharatum or Chinese sugar-cane, pp. 286-287.

Proc. Amer. Acad. Arts and Sci., iii, 1857.

Remarks on the copper and gold mines of North Carolina and on the coal region of Deep river, N. C., pp. 68-69.

Analysis of water from Sacramento river, Calif., p. 196.

Remarks on crustacea in Cochituate water, p. 252.

Prospectus of the American Exchange Mining and Smelting company. Letter to Messrs. Henry B. Elliott and associates. Baltimore, Md., June 16th, 1857. Copy in Mrs. Jackson's possession.

1858.

Proc. Boston Soc. Nat. Hist., vi, 1859.

Analysis of the supposed meteoric stone from Marblehead, Mass., pp. 294-295. Resembled slag of a copper smelting furnace.

Remarks upon the Chinese sugar-cane, pp. 293-297; 299-300.

Remarks on the presentation of a Chinese yam (Discorea batatus), p. 337.

Remarks on the presentation of the earth almond (Cyperus esculentus), p. 337.

Remarks on the exhibition of a sample of crystallized sugar from Chinese sugar-cane, p. 337.

Observations on oölite ore from Wisconsin, p. 341.

On the Chinese sugar cane, pp. 341-342.

Repetition of communication on fluorine in fish scales, p. 366.

Remarks on the presentation of the geological maps of the United States and New Mexico, by William McClure and M. Marcou, p. 368.

Observations on insectivorous insects, p. 400.

(With H. S. Piggatt.) Gardner Hill Mining company, prospectus, charter and reports. Baltimore, 1858. 8vo, pp. 15.

1859.

Proc. Boston Soc. Nat. Hist., vi, 1859.

On tobacco (Nicotiana tabacum) from Hatfield, Mass., pp. 408-409.

Ibid., vii, 1861.

Observations on the preservation of animal tissues by arsenic, p. 5.

Remarks on exhibition of Tetradymite and Itacolumite associated with native gold from Georgia, pp. 22-23.

Remarks on coloring matter from a red beetle (Reduvius), p. 24.

Remarks on pyrophyllite from Lincoln Co., Ga., pp. 24-25.

Observations on dye from the red bug (Reduvius), p. 29.

Remarks on the corrosive properties of Mexican guano, pp. 29-30.

Remarks on tartaric acid in American wines, p. 30.

A sketch of the theory of metamorphism as now adopted, pp. 30-31. "Anthracite coal fields of Pennsylvania acted upon by hot water under ocean pressure, a satisfactory explanation."

Mode of formation of native copper and silver of lake Superior, p. 31. "From the chlorides of these metals in contact with iron."

Remarks on the action of gases from volcanic eruptions in killing fish, p. 39. Action not due to heat, but to sulphurous, sulphuretted hydrogen and chlorohydric acid.

Remarks on the peculiarities of thermal springs, pp. 45-47. In the Vosges, Roman baths, lake Superior, etc.

On the silky growth from the base of the fronds of tree ferns, p. 48.

On Tuckahoe or Indian bread, a fungus growth in the southern states, p. 48. Contains no starch but cellulose and mucilage.

Remarks on a trilobite from the calcareous slate at St. Mary's bay, Newfoundland, p. 64. Identical with Paradoxides harlani; formation can be traced from Braintree to Newfoundland.

Remarks on the so-called Japanese wax produced from the berries of Rhus succedaneum, pp. 54-55. Is not a wax.

Remarks on the most natural route for a railroad to the Pacific, p. 70. From New Orleans via Texas and N. Spain to Mazatlan.

Remarks on the death of Alexander von Humboldt, pp. 70-71.

Remarks on specimens of Paradoxides from Braintree, Mass., and St. Mary's Bay, Newfoundland. The latter in a boulder; measurements given. P. harlani.

Observations on search for coal in rocks carrying fernlike impressions and markings resembling lepidodendron near Pembroke, Me., p. 75. Opinion of futility of search somewhat shaken.

Report on the frozen well at Brandon, Vt., (with Mr. J. H. Blake). pp. 81-84. Opinion as to cause reserved.

Observation on the relations of rocks at Perry, Me., to the Silurian, p. 86. Rest on Silurian.

In regard to frozen wells at Brandon, Vt., and Oswego, N. Y., p. 135.

Remarks on specimens of a compact specular iron ore from Phillipsburg, N. J., p. 136, Occurrence described.

Remarks on the wax plant of Japan (Rhus succedaneum) and on the tea plant, pp. 149-150.

Remarks on white marl in the bottom of a pond in New Hampshire, p. 151.

Remarks on the discovery of tin ore at Los Angelos, p. 152.

Allusion to sugar in native grapes, p. 152.

Remarks on green feldspar from sea-wall near Southwest Harbor, Me., p. 160. Amazon stone; hitherto known only in Siberia,

Remarks on artificially produced minerals received from M. Daubree, p. 160.

Remarks on a meteorite from Oregon, p. 161: also pp. 174, 175-176, 191, 279.

On the position of the Roxbury conglomerate, p, 183. Dissents from Marcou's view that it belongs to the "new red sandstone," maintains that it underlies the coal.

1860.

Proc. Boston Soc. Nat. Hist., vii, 1861.

Remarks on the elongated pebbles found in the conglomerates at Newport and in Vermont, p. 209. Thought no change has taken place since deposition. Averse to any theory which requires softening after deposition.

Remarks on a pearl covered secretion from a Unio from Michigan, p. 278.

Remarks on a memorial to Congress in relation to the Oregon meteorite, p. 289.

Observations upon the bituminous and coal deposits of the Albert mine, New Brunswick, p. 295.

Analysis of the juice of the leaf-stalks of the garden rhubarb (Rheum rhoponticum), p. 305.

Remarks on the reopening of old mines in New Hampshire, p. 349. Fronconia iron mine; argentiferous galena at Warren; copper at Bath.

On andalusite macle in an altered argillaceous slate on Mt. Washington, pp, 349-350. Boulders of it at Boar's Head, near Rye, N. H.

Remarks on the formation of the distorted and indented pebbles at Newport and Roxbury, p. 354, Thought they might be formed by beach action, but thought the Vermont pebbles might have been formed by segregation from the rock. Notes decay to depth of from 80 to 100 feet at Dahlonega, Ga.

Proc. Amer. Acad. Arts and Sci., iv, 1860.

Observations on Tetradymite from Spottsylvania, Va., Bornit from Dahlonega, Ga., also gold, p. 192.

Analysis of Bornite from Dahlonega, Ga., p. 196.

Vegetable wax from Japan; Trilobite from Newfoundland, p. 199,

Olivine bearing meteorite from Rogue river, Oregon, p. 359.

Amer. Jour. Dental Sci., x, 1860.

Influence of the sun's rays in the production of organic matter, pp. 557-560.

Boston Medical and Surgical Journal, liii, 1860.

Influence of the sun's rays in the production of organic matter, pp. 213-215.

Existence of nitrogen in plants, its origin in animals, pp. 289-292.

Statistics of poisoning in New England, pp. 389-391.

1861.

Proc. Boston Soc. Nat. Hist., vii, 1861.

Remarks on the age of red sandstones at Perry, Me., Nova Scotia, Keweenaw Pt., and of the Albert coal in New Brunswick, pp. 396-398. Considers Keweenaw rock as Trias (Marcou); fossils from Perry indicate Triassic age.

Announcement of the occurrence of andalusite macle between Boar's Head and the White mountains, p. 418. At South Berwick, Me.

Remarks on a specimen of Boghead coal from Torbonnehill, Scotland, p. 422. Considered Stigmaria the underground stem of Sigillaria.

Remarks on coal from the gulf of Chiriqui, p. 423. Probably of Eocene age: analysis given. Also Proc. A. Ac. Arts and Sci., v, 1862, p. 112.

Remarks on a microscope, p. 423. Inverted microscope of J. Lawrence Smith.

Additional notes on the fossil shells and coal from Chiriqui, p. 428. Analysis; microscopic examination showing cellular plants.

Proc. Amer. Acad. Arts and Sci., iv, 1860.

Remarks on marble used in the buildings in Washington, p. 5.

Remarks respecting the Morse magnetic telegraph, p. 100. "Alleged that he himself first made known to Mr. Morse the general idea of the invention, and of the principles upon which it depended."

Proc. Boston Soc. Nat. Hist., viii, 1862.

Remarks on Paradoxides from Braintree and Newfoundland, p. 58.

Remarks on the red color in zincite, p. 145.

Remarks on the occurrence of gold in the United States, p. 172. Hematite of N. C. and Ga. contains gold, iron pyrites does not, but may be mechanically mixed.

Remarks on the decease of Dr. John Evans, U. S. Geologist, p. 177.

Observations on Boue's geological map of the world, etc., pp. 177-178. Also notes Marcou's map of U. S. A.

Fragments of rolled corals from the soil of Cumberland county, N. J., p. 226. Tertiary according to Rogers and Agassiz.

Chemical analysis of a meteoric stone from Dhurmsalla, India, pp. 233-235. See also Proc. Amer. Acad. Arts and Sci., v, 1862, p. 359.

A manual of etherization: containing directions for the employment of ether, chloroform, and other anæsthetic agents, by inhalation, in surgical operations,....comprising also a brief history of the discovery of anæsthesia. Boston, 1861, pp. 134. List of papers on anæsthetic use of ether and chloroform, pp. 125-127. Review of, Boston Medical and Surgical Journal, LXV, 1861, pp. 292-294.

Manual of etherization. With instructions for the preparation of ether and chloroform, and for testing them. Also a brief history of the discovery of anæsthesia. Boston, 1861, pp. 12. Harvard Univ. Catalogue. (Not seen.)

Boston Medical and Surgical Journal, lxv, 1861.

Hints to army surgeons, 109-111.

Ibid., lxiv, 1861.

First practical use of ether in surgical operations, pp. 229-231. Evidence concerning Dr. C. W. Long.

Tabular statement of deaths attributed to the effects of inhaling chloroform, 259-261.

Detection of strychnia in the substance of the blood, pp. 337-339.

1862.

Proc. Boston Soc. Nat. Hist., viii, 1862.

Remarks on a specimen of Domeykite from the vicinity of Portage lake, lake Superior, p. 258. Sp. G. 7.431 and not 4.5.

Ibid., ix, 1863.

Remarks on the recent discovery of gold in Nova Scotia, p. 47.

Remarks on the manufacture of writing inks, p. 55.

Observations upon metamorphic action in eastern Massachusetts and Rhode Island, p. 57. Superheated water must accompany dikes.

Remarks upon crystallized glass, p. 70.

Remarks upon the death of Mr. Henry D. Thoreau, pp. 70-72.

Report of the committee appointed to examine the frozen well at Brandon, Vt., pp. 72-88. (With John H. Blake and William B. Rogers.)

Remarks upon a new method of security against counterfeits in paper currency through the introduction of determinate species of Diatomaceæ into the material of the paper, p. 155.

Proc. Amer. Acad. Arts and Sci., v, 1862.

Comments on a letter from M. Moissent in regard to a new gas engine, pp. 51-52. (Unpublished.)

Report upon the property of the Black River mines, situated in Lotbeniere county, C. E., Oct. 22, 1862. Boston, 1862, 8vo, pp. 7 plus.

The Halifax Copper Mine. Boston, Aug. 18th, 1862. To Carlos Pierce, Esq., pp. 7. Rock "appears to belong to the Taconic system of Emmons, or to the lowest Silurian of Murchison."

Report on the property of the Chaudiere mine. Boston, 1862, 8vo.

Report on the Wickham copper mine. Boston, 1862, 8vo, pp. 8.

Boston Medical and Surgical Journal, lxv, 1862.

Influence of the position of animals under the effects of ether, p. 508.

1863,

Proc. Boston Soc. Nat. Hist., ix, 1865.

Sketch of the copper-bearing belt in Canada, pp. 202-203.

Remarks on the mode of occurrence of Galena at Dubuque, pp. 222-224. Notes on copper and iron ores formed by sublimation.

Report on the Shepherd copper mine in Sutton, C. E. (Petherick, Thomas.) Reports, etc., 1863, 8vo, pp. 10-13.

Report, etc., (Mineral Point Mining Co.) 1863, 8vo, pp. 6-8.

Report upon the Plumbago Mining Co., situated in Puzzle mountain, Neury, Oxford county, Me. (With N. T. True.) Issued by Edward G. Tileston & Co., Boston, 1863, 8vo, pp. 11. Pamphlet in Harvard College library.

Report on the property of the Megantic mine, Halifax, Boston, 1863, 8vo, pp. 8.

Report on the property of the Abercrombie Gold Mining Co. Boston, 1863, 8vo, pp. 6.

(With R. Bennett.) Reports on the property of St. Margaret's Copper mine. Boston, 1863, 8vo, pp. 7.

Boston Medical and Surgical Journal, lxvi, 1863.

Remarks upon the late Dr. L. V. Bell, pp. 73-74.

1864.

Report (Boston and Corinth Copper Mining Co.), 1864, 8vo, pp. 5-6. (Harvard College catalogue.)

Proc. Boston Soc. Nat. Hist., ix, 1865.

Exhibition of specimens of Jersey tea (Ceanothus Americanus) growing on the old red sandstone of Pennsylvania, pp. 333.

Ibid., x, 1866.

Notice of the death of Francis Alger of Boston, pp. 2-6. B. March 8, 1807, Bridgewater, Mass. List of scientific writings.

Presentation of specimens of rock salt from the Petit Anse salt mines of Louisiana, p. 17. (Unpublished.)

Remarks on the habits of the beaver, p. 41. (Unpublished.)

Account of a scientific journey through California and Nevada via Panama, pp. 224-229. Observed a meteorite; determined its altitude.

Exhibition of diaspore from Chester, Mass., p. 240. (Unpublished.)

Remarks on drift scratches and glacial deposits, pp. 245-246. Cannot be due to glacial ice. Notes granite boulders in clay beds, 60 feet thick, on Block island, traced to Kingston, 15 miles in a northeasterly direction.

On Cretaceous fossils collected at Santa Barbara and on the quicksilver deposits there; the borax of Lake county, Calif., and the oxide of tin near Los Angelos, etc,, pp. 262-263.

Remarks on specimens of polished rocks from Smoky Valley, Nevada, pp. 303-304. Due to joint effect of snow and sand sliding, finished up by the more delicate touch of blowing sand, in prehistoric times—no sand there now.

Account of the mines of California and Nevada, p. 308. Unpublished.

Chemical analysis of minerals associated with the emery of Chester, Mass., pp. 320-322. Andesine, diaspore, margarite, clinochlore or chlorotoid.

Ibid,, xi, 1868.

Remarks on Kackum oil, an indelible ink nut, Ghantee root, and Cashew nuts, p. 31.

Observations on ice forming in summer and disappearing in winter, p. 32. Cases in Russia and at Brandon, Vt.

Observation on the occurrence of veins of dolomite in the Emery mine at Chester, Mass., p. 32. Contained a crystallized sapphire.

Proc. Amer. Acad. Arts and Sci., vi, 1866.

Remarks on examination of pyrites for nickel, p. 81.

Description and analysis of a meteorite from Decotah, pp. 166-167. Iron-nickel-tin-phosphorus contents, 100 lb. specimen.

Paris Acad. Sci., Compt. Rendu., lviii. 1864.

Observations sur des gêtes métalliféres de quelques parties de l'Amerique septentrionale et sur un nouvel aerolithe, pp. 240-242.

(With D. McCaine.) Groton soapstone quarry. Boston, 1864, 8vo, pp. 16.

1865.

Proc. Boston Soc. Nat. Hist., x, 1866.

Analysis of iron ore from the northern end of Staten island, p. 72.

Remarks on prepared peat, pp. 72-73.

Presentation of specimens of carboniferous plants from the Wyoming coal basin of Pennsylvania, and pamphlets by Elie de Beaumont on his pentagonal system of mountain chains, pp. 80-81. Urges American geologists to study de Beaumont's hypothesis.

Discovery of emery in Chester, Mass., pp. 84-90. Gives section, p. 86. A single banking house in London had a monopoly on the deposits in the Grecian archipelago. One of his important interests but the mine was discovered by Dr. H. S. Lucas. Also Paris Acad. Sci., Compte Rendu, LX, 1865, pp. 421-423.

Paris Acad. Sci., Compt. Rendu, lxi, 1865.

Nouveaux details sur les mines d'argent du Nevada, pp. 998-999. Also Cosmos III, 1866., pp. 66-67.

Sur les mines d'or et d'argent de la Californie, pp. 947-950.

1866.

Amer. Jour. Sci., (II) xlii, 1860.

Analysis of some minerals from the emery mine of Chester, Mass., pp. 107-108. Andesite, margarite, and diaspore, by John C. Jackson, fils; chlorotoid.

On the discovery of Corundum at the emery mine, Chester, Mass., p. 421. Finds perfect crystals of sapphire three inches long.

Proc. Boston Soc. Nat. Hist., x, 1866.

Remarks on calcite veins from Martensburg. N. Y., p. 97.

On coating eggs with soluble glass to prevent entrance of spores, p. 98.

Remarks on petroleum, p. 103, (Unpublished.)

Remarks on green feldspar or Amazonian stone from the granite quarries of Rockport, Mass., pp. 167-168. Mentions other minerals found there.

1867.

Amer. Jour. Sci., II xliii, 1867.

Analysis of a meteoric iron from Colorado, pp. 280-281.

Proc. Boston Soc. Nat. Hist., xi, 1868.

Remarks on the death of Dr. A. G. Gould, p. 27.

Analysis of meteoric iron from Bear river, Colorado, pp. 71-72. See Amer. Jour. Sci., next above.

Remarks on the non-occurrence of meteorites in sedimentary strata, pp. 82-83.

Remarks on the touchstone used by watchcase makers, pp. 114-115. Use a polished block of bazanite with 12 gold "keys" of known composition.

Observations upon the alewife in Massachusetts, p. 131.

Observations upon fossils from the green sand of New Jersey, p. 158. Considered same as greensand of England and France.

Remarks on the gold region of Vermont, pp. 243-244. $4 to $12 a ton.

1868.

Proc. Boston Soc. Nat. Hist., xi, 1868.

Chemical analysis of fossil guano from the vicinity of Charleston, S. C., pp. 392-393.

Remarks on the modern methods for the preservation and coloration of wood, pp. 462-464.

Proc. Amer. Acad. Arts and Sci., vii, 1868.

Description of a series of lead-encased block-tin tubes for the conduction of water, pp. 433-435.

Proc. Boston Soc. Nat. Hist., xii, 1869.

Analysis of green Petrosilex from Melrose, Mass., p. 84.

Description of the beds of apatite in North Burgess, Canada West, pp. 88-89. Phosphate of lime not necessarily of organic origin.

California Acad. Sci., Proc. III, 1868.

Measurements of the hight and circumference of twenty-five of the "big trees" (Sequoia gigantea) in Calaveras county, pp. 204-205. Taken in 1865.

1869.

Proc. Boston Soc. Nat. Hist., xii, 1869.

Cited on Portland landslide, p. 236.

Description of a new locality of tin ore in Winslow, Me., p. 267.

Ibid., xiii, 1871.

Remarks on native carbonate of magnesia from Greece, California, Maryland and Kansas, p. 172.

Paris Acad. Sci., Compt. Rendu., lxix, 1869.

Sur les mines de cuivre du Lac Superior, et sur un nouveau gisement d'etain dans l'état du Maine, pp. 1082-1083.

1870.

Proc. Boston Soc. Nat. Hist., xiii, 1871.

Remarks upon Mr. Shaler's views of the relations of the rocks in the vicinity of Boston, pp. 177-178. "When it is alleged that crystallized rocks like syenite or granite, are altered sedimentary rocks of aqueous origin, we require that the passage state should be demonstrated and this has never been done by any who has advocated such a metamorphosis."

1871.

Remarks upon meteorites, p. 412. Inferred that the fall of meteorites is of modern occurrence—since the tertiary strata were deposited.

Proc. Boston Soc. Nat. Hist., xiv, 1872.

Letter to nominating committee, Boston Soc. Nat. Hist., p. 2. Cannot consent to become a candidate for the presidency.

Glacier theory of drift, pp. 65-68; 73. Has not been able to adopt the glacial theory of drift phenomena.

Observations upon expansion of rocks due to change of temperature, p. 87.

Remarks on the eruptions of Etna and Stromboli, p. 128.

Remarks on quartzites and slate, p. 129.

Remarks on the action of the poison of the rattlesnake, pp. 133-134.

1872.

Proc. Boston Soc. Nat. Hist., xiv, 1872.

Remarks on Lingula, p. 218. (By title only.)

On the elevation and depression of the Atlantic coast, p. 218. (Unpublished.)

Observations on the occurrence of crystal globes in the Druid mounds of England, p. 305. Thought they were derived from Japan.

Report on the Brandon frozen well, pp. 306-308. Chemical analysis of the water: gravel bed frozen by cold of former vigorous winters.

Remarks on the transportation of boulders in New England. p. 386. Repeated.

Remarks on Labrador feldspar in New Hampshire, p. 392. Not found *in situ.*

Ibid., xv, 1873.

Remarks on pebbles at Newport and Chestnut Hill, p. 3. Could not

admit that these pebbles were ever plastic and attributed their form to the action of water.

Observation upon the failure of earthquake shocks to affect deep mines in California, p. 187.

Letter to Samuel F. B. Morse, dated Boston Nov. 7th, 1837. In "A memorial of Samuel F. B. Morse, from the city of Boston. Public Document, 1872, p. 75-77. Relates to invention of magnetic telegraph.

Relations of syenite at Richmond, elevation of coast of Hatteras region and Maine. Amer. Nat., v, 1872, p. 181.

1873.

Proc. Boston Soc. Nat. Hist., xv, 1873.

Analysis of meteoric iron from Los Angelos, Cal., pp. 254-255.

Remarks on the geological survey of New Hampshire, p. 309. Map could not be colored for want of time, thought no inference could be drawn from fossils found by Hitchcock at Littleton.

Remarks on the death of Dr. Henry Coit Perkins, pp. 310-311.

(Posthumous). 1887.

Catalogue of rocks, minerals, and soils, collected during the geological survey of Rhode Island, summer of 1839. Providence Franklin society, report on the geology of Rhode Island. Providence, 1887, pp. 58-68. This list is based upon two MSS., copies in the possession of the society; probably not before printed.

REVIEWS AND WORKS GROWING OUT OF JACKSON'S PUBLICATIONS.

Review. First report of the geology of the state of Maine. Amer. Jour. Sci., XXXII, 1837, pp. 193-194.

C. U. Shepard. Report, Chester emery mine, 18—, p. 6. Objects to Jackson's considering emery a distinct species from corundum. Cited by B. K. Emerson, Mineralogical Lexicon, p. 62.

Dall, W. H., and G. D. Harris. Correlation papers, Neocene. Bull. 84, U. S. Geol. Survey, Washington, 1892, pp. 32-33. Dr. Jackson's tertiary deposits of Maine, probably quaternary, p. 34. Views on Tertiary deposits in Rhode Island unsupported.

Foster, J. W. and J. D. Whitney. Report on the geology of the lake Superior land district, pt. II, Washington, 1851, p. 137. Jackson's argument for superior position for lake Superior sandstone controverted.

Van Hise, C. R. Correlation papers, Archæan and Algonkian. Bull. 86, U. S. Geol. Survey, Washington, 1892., p. 384. "Jackson, among the older geologists, has steadily maintained the essentially igneous origin of the granites and syenites." Reviews Jackson's work on these rocks.

Hamel, D. Historical account of the introduction of the galvanic and electro-magnetic telegraph. London, August. 1859, pp. 71. Mentions C. T. Jackson's claim. Copy in Mrs. Jackson's possession.

A large number of pamphlets and irregular publications sprang up in connection with the "ether" controversy, involving the claims of Jackson, Morton, and Wells. See Littell's Living Age, No. 201, March 18, 1848. It has not been thought necessary to collect a full list of these.

Editorial. Inhalation of ether in surgery. Amer. Jour. Sci., III, 1847, pp. 444-447, p. 445.

Sims, J. Morion, M. D. History of the discovery of anæsthesia. Virginia Medical Monthly, May, 1877, pp. 14. Reprint, Richmond. 1877; New York, 1879. Anæsthesia by use of sulphuric ether, demonstrated by Crawford W. Long, M. D., at Jefferson, Jackson Co., Ga., March 30th, 1842.

H. J. Bigelow. Insensibility during surgical operations produced by inhalation. Boston Medical and Surgical Journal, XXXV, pp. 309-317. See this and subsequent volume for numerous references to the subject.

BIOGRAPHIES OF DR. JACKSON.

Warren, G. Washington: Resolution concerning Dr. Charles T. Jackson. Proc. Boston Soc. Nat. Hist., XVII, 1875, p. 14.

Editorial. The late Dr Jackson. The Springfield Daily Republican, Sept. 9th, 1880.

Barber, William: Dr. Jackson's discovery of ether. The National Magazine, Oct., 1896, v, 46-58. Gives views of his birthplace, residence in Somerset St., Boston, and of medals received.

Emerson, Edward Waldo: A history of the gift of painless surgery. The Atlantic Monthly, LXXVIII, Nov., 1896, pp. 679-686. Cites Dr. Morrell Wyman. "Jackson was the head and W. T. G. Morton the hand."

Anon: Sketch of Dr. Charles T. Jackson. Pop. Sci. Monthly, XIX, 1881, pp. 404-407.

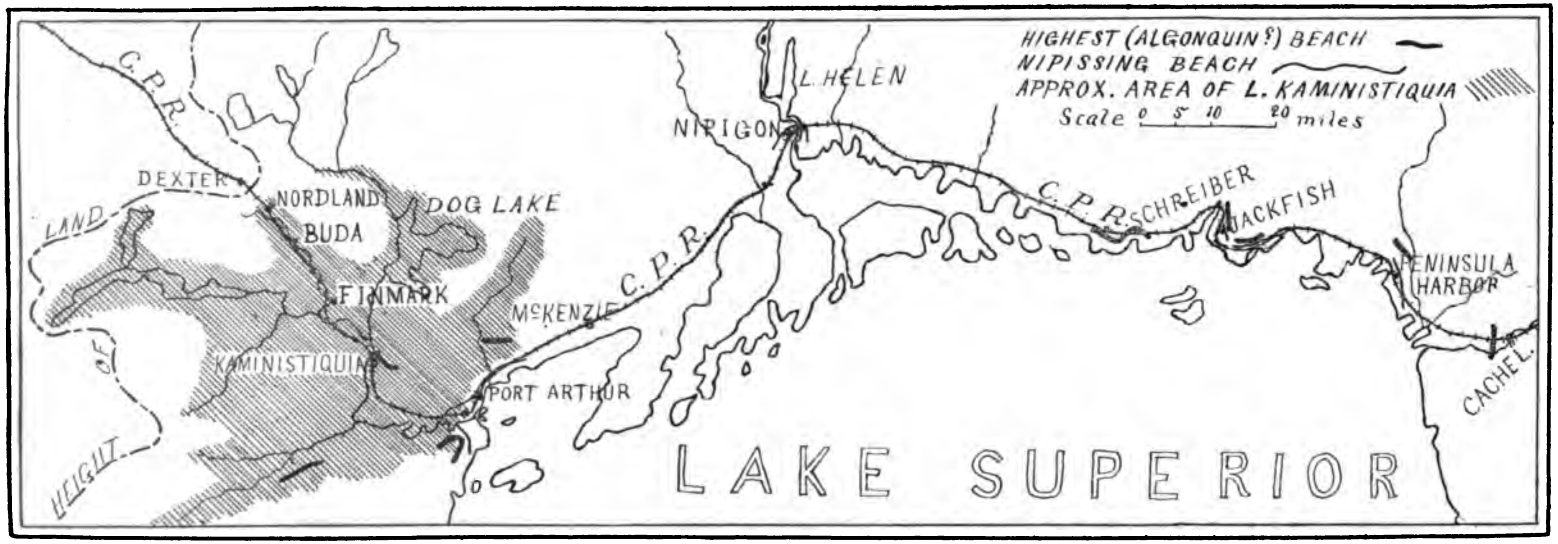
Anon: Charles Thomas Jackson. Proc. Amer. Acad. Arts and Sci., XVI, 1881, pp. 430-432. Ether controversy led to his insanity. He suggested ether anæsthetics.

Bouvé: T. T.: Historical sketch of the Boston Society of Natural History. Ann. Memoirs, Boston Soc. Nat. Hist., 1880, pp. 167-168. Brief sketch of Dr. C. T. Jackson.

Bouvé, T. T.: Biographical notice of C. T. Jackson. Proc. Boston Soc. Nat. Hist., XXI, 1881, pp. 40-47.

Bartol, C. A.: Charles Thomas Jackson. Boston Daily Advertiser, 1880.

The author is indebted to Miss Anna J. Knight of Boston for the use of the cut accompanying this paper, and to Mrs. C. T. Jackson of Concord, Mass., and to numerous friends for information concerning the life of Dr. Jackson.



ALGONQUIN (?) AND NIPISSING BEACHES ON THE NORTH SHORE OF LAKE SUPERIOR.

NOTES ON THE ABANDONED BEACHES OF THE NORTH COAST OF LAKE SUPERIOR.

By FRANK B. TAYLOR, Fort Wayne, Indiana.

[Plate V].

The month of September, 1895, was spent by the writer chiefly in searching for abandoned beaches on the north coast of lake Superior.* This coast was studied by Prof. A. C. Lawson in the summer of 1892 with special reference to evidences of submergence, and his observations are recorded very fully in his report entitled "Sketch of the Coastal Topography of the North Side of Lake Superior with Special Reference to the Abandoned Strands of Lake Warren."†

The high value of Prof. Lawson's observations was not questioned, but his methods of correlating the abandoned strands observed at different localities, and the general conclusions which he based on this correlation have been reviewed and discussed in papers already published.‡ By reference to Prof. Lawson's report it will be seen that he tabulated his results at forty-eight localities between Duluth and Sault Ste. Marie in a substantially horizontal series.§ He supposed the greatest interval between the varying hights of any single continuous strand to be about thirteen feet.‖ His conclusion in substance is that the abandoned strands of the north Superior coast are almost as perfectly horizontal, when compared with the present lake surface, as they were when they were made, and therefore, that, although this coast has been greatly uplifted relatively, it has not suffered any notable irregularity or deformation. That is to say, the region appeared to have been greatly uplifted, but so evenly over the whole area that the strands retained their horizontality after elevation. This was not the case on the south coast of lake Superior nor on any other coast of the upper lakes so far as known to the writer. It seemed to the writer that in his detailed description Prof. Lawson has not shown facts that could form an ade-

*The results were briefly stated in a letter published in the AMER. GEOL., for April, 1896, p. 253.

†Twentieth Annual Report of the Geol. and Nat. Hist. Survey of Minn.

‡AM. GEOL., vol. XIII, June 1894, pp. 380-383: same, vol. XV, March 1895, pp. 119-120; same, vol. XV, May 1895, pp. 304-314.

§Table opposite page 280.

‖Table on page 285.

quate basis for his scheme of correlation or his conclusions. Indeed, some of his observations seemed to indicate a considerable slope for the highest strand in the west end of the basin. Later a closer study of his description of the lower beaches seemed to show quite clearly that the Nipissing beach is in its normal place on that shore, rising about 125 feet from Duluth northeastward to Peninsula Harbor.*

In discussing Prof. Lawson's conclusions the writer admitted in the earlier papers referred to that on general principles the lower shore lines, which are the youngest and newest, might still be substantially horizontal, but maintained that the higher lines, and especially the highest one, which is the oldest of all, must express in the position of its plane the composite results of all the movements which have occurred since it was made, and further that on this account it could hardly be expected that it would be left finally in a horizontal position. These contentions seemed sound enough on general principles, but were in part curiously reversed in the results attained in 1895.

The Nipissing beach was found in its normal place, rising from about 55 feet above lake Superior on the eastern base of Mt. McKay near Fort William to about 115 feet at Peninsula Harbor at the extreme northeast angle of the lake. But so far as observed the highest beach that extends continuously along the north shore was found to be nearly, but not perfectly, horizontal.

Port Arthur. In passing the north end of Isle Royale and between Thunder cape and Pie island a low terrace could be seen quite distinctly in several places. It is a plain feature on the north end of Pie island, and is probably a fragment of the Nipissing beach. Lawson reports a broad terrace there which abuts against a talus of great blocks at 43.5 feet. Probably the back of the terrace was covered up, for the Nipissing beach was clearly identified on the main shore in or near Port Arthur at about 60 feet. (61.4 feet as levelled by Lawson.)

Mt. McKay was ascended up to the "first level" or great shelf which is about 500 feet above the lake. In the two miles of swamp between the Mission and the eastern foot of the mountain several sandy ridges of a littoral character were crossed

*Am. Geol., vol. xv, May 1895, page 313.

at a hight of 50 to 60 feet. In the ascent of the mountain a great beach ridge of shingle was found at an altitude of 155 feet. It is composed mostly of small slabs and flat fragments of the Animikie slate which underlies the columnar trap of the mountain. The stones are pretty well worn by wave action, most of them having a rudely lenticular form. Some of them are as much as eight or ten inches wide, and two or three thick. This ridge has a distinct lagoon hollow behind it, although it lies on a very steepslope. The ridge is not unusually wide, but its lower edge is about fifteen feet below its crest. It is probably compound, but no distinct evidence of this was noticed. This strong ridge appeared to be the lowest one of a series extending up to about 210 feet, several of which are well developed. Much of the mountain slope seemed unfavorable for any permanent record. It is too steep, the rock fragments are too large. Besides, a large amount of talus of later origin has fallen down over much of it. A beach ridge of shingle, quite distinct, but not so strong as some of those lower down was found at a hight of about 440 feet. It is so heavily overlain by talus at the point observed that it is not certain that the part seen is the highest mark of wave action, but none higher were observed.

The central part of the great shelf on the mountain is a swampy thicket, but the northern and eastern edges are more accessible. No evidence of wave action was found on this level, nor any of still-water sedimentation, unless a thin, light yellow loam that appeared to cover gravelly drift in some places might be taken as such. The floor of the shelf along the north edge is bare and has the appearance of having been polished smooth by glacial action. No striæ of entirely certain identity were found, but some very faint lines and the *roche moutonnée* contours of the slightly rolling, polished rock surface seemed to indicate that the ice moved toward the west, and a little to the north of west.

A drive was made to the Beaver mine in the valley of White Fish river, 24 miles west southwest from Port Arthur. On the Oliver road, half a mile or more southwest of town the Nipissing beach is finely formed with a bluff 15 to 20 feet high at its back. Beach ridges were crossed at a point six miles out about 240 feet above the lake. South of Murillo on

the Canadian Pacific railway the road crosses a sandy rolling plain which is apparently an old delta of the Kaministiquia river. The top of this plain is 240 to 260 feet above the lake and is about at the level of the top of the famous Kekabeka falls three or four miles to the west. The eastward or down-stream front of this plain is distinctly cuspate, having the appearance of being cut by long winding gullies. These show the composition of the plain to be mostly of sand. A little to the north of Stanley on the Duluth and Port Arthur railway the blue clays mentioned by Lawson* appear underlying the sand. In one bank they appeared to be distinctly laminated. But in several other exposures no distinct horizontal layers were detected. South of the river at Stanley the road ascends a bluff of gravelly blue clay. At about 180 feet above the lake fine wavy blue clay was found free of stones and gravel and having a humpy, rolling surface. At a point about two miles from Beaver mine the road follows a long shelf on the south side of the valley, which at this hight is at least five or six miles wide, widening towards the northeast. Along the edge of this shelf there is in some places a gravel ridge which is probably a wave-made beach. Its hight is approximately 450 feet above the lake. At Beaver mine, and on the hill back of it, no evidence of submergence at higher levels was seen.

In the town of Port Arthur the several features described by Lawson were easily recognized. To his report on this place† I add only such observations and conclusions as are new, or at least not mentioned by him. The lower of his terraces, backed by a sharp sea-cliff at 61.4 feet, was readily recognized as the Nipissing beach. Lawson's photographic view‡ looks northward on this terrace, with the sea-cliff on the left. The point from which the view was taken was easily found. The newness of this terrace as compared with those above it, shown by the comparative amount of erosion, where creeks and streams cross it, seems not to have been noticed by Prof. Lawson on any part of this coast. Evidence of this kind was not found quite so conspicuous in Port Arthur as at some other places to be described later. But when this quality was once

*Ibid., pp. 210-211.
†Ibid., pp. 262-263.
‡Plate IX, Fig. 1, opposite p. 262.

recognized it became a valuable aid in identifying this beach at places widely separated. Its great strength, however, is the most reliable character for its recognition. Sometimes this quality may not appear to be striking at a given locality, but it generally makes its appearance soon if the beach is followed for any distance along the shore. Back of the town the great hooked spit at 170 feet on the south side of the Dawson road was found as described by Lawson. The most of the material for the spit appears to have been drawn from a hill of drift which formed a salient point east of the road and above the town. At the top of the hill and just north of the road a lightly formed beach not mentioned by Lawson was found at about 210 feet. It takes the form of a gentle, boulder strewn slope towards the south, and it has a low sea-cliff at its back.

After crossing the first hill-top west of town on the Dawson road and descending the west side a large sandy beach ridge was crossed at 170 feet, the level of the hooked spit just noted. About five miles out faint sandy beaches were found at 370 and 380 feet above the lake. A broad plain at 410 to 420 feet, eight miles out, may be related to a higher beach, but higher ground was not seen in that vicinity.

On a drive to the old Thunder Bay mine northeast of Port Arthur and up the north branch of Current river, several interesting evidences of submergence were observed. Starting northward from the post office the road follows the terrace of the Nipissing beach near its highest level to the outskirts of the town and then turns west through a cut in the old sea-cliff to the higher terrace. Less than a mile out a fine sandy beach running southwest is crossed by the road at about 110 feet above the lake. Clean-washed rounded gravel was found at 180 feet just south of the bridge over Current river. The gravel forms a plain and is part of an old delta, which is still more extensive on the north side of the river. Its surface slopes gradually towards the lake and is covered by a numerous series of low beach ridges of fine gravel and sand. The highest part crossed by the road is about 190 feet above the lake. About a mile northeast of the bridge an old lumber road turns off northward up the north branch of the river. This road crosses the outer edge of an old delta at about 210 feet.

Farther on it ascends a massive ridge of gravel which projects from the east, and ends abruptly as a high bluff overlooking the river. The top appears to be a beach, and the whole ridge is probably a great spit. Its hight is about 260 feet. Less than two miles farther north the road crosses a great terrace, now a muskeg and cedar swamp, which has what appeared to be a sea-cliff at its back cut out of irregular morainic hills of drift. The back of this terrace is about 450 feet above the lake. From the hills above, a fine view is had of Thunder bay and Pie island in the distance. The highest point reached was 70 feet above this terrace. At a point about two miles north of Port Arthur the Canadian Pacific railway passes up over the Nipissing beach, which is here marked by a low rock cliff extending for some distance. The railroad then ascends gradually over a sandy plain with many ridges, and passes into a region of bare rocky knobs.

Two trips were made from Fort William westward up the main line of the same railroad. The first was to a point two miles north of Finmark and the second to Dexter, 55 miles from Fort William and near the top of the grade. Both trips were made on freight trains and most of the time was spent outside on top where the seeing is best. This is the best way to get a glimpse at that wild region, for there are no wagon roads. The old Dawson road is passable as far as Kaministiquia station, 20 miles west of Port Arthur. But at this point the bridge is gone and the old trail beyond is not passable. Fort William is on a low flat delta of the Kaministiquia and the tracks of the railway are only three or four feet above the lake. About three miles west of West Fort William the track crosses a series of sandy beach ridges and a sand bluff about 15 feet high. The beach is about 60 feet above the lake and is beyond a doubt part of the Nipissing beach. The plain close above and back from the edge of the bluff is deeply trenched by small streams which flow in very narrow, steep-sided trenches with meandering courses. The trenches reach back an eighth of a mile or so from the bluff. Except a few fragments of low sandy ridges, no other conspicuous relics of submergence were noted until Kaministiquia station was reached. Here is the great gravel delta described by Lawson,* at an al-

*Ibid., p. 262.

titude of 455.1 feet. The extensive ballast pit below the station shows the gravel in fresh exposure 30 feet high. Considering the way in which the old delta was shut in between the hills and the comparatively coarse quality of much of the gravel, it seems probable that its surface at the pit does not mark the old water level, but is somewhat higher. The structure of the delta was not very well shown except in the upper part above the talus where the layers were horizontal.

Lake Kaministiquia and the Sunshine Red Clay. A short distance above Kaministiquia the railroad crosses the river and turns away westward and within a few miles farther enters the valley of Sunshine creek which it follows nearly to its source. Three or four miles beyond Kaministiquia the cuts along the railway begin to disclose sections of fine red clay. The frequency and depth of these clay sections increase until, from a point two or three miles south of Finmark to a point four or five miles beyond this place, the clay appears to form an almost complete mantle over the drift and rocks of the valley floor and many sections 15 to 20 feet or more in depth may be seen. The color of this clay is bright red. It is fine and smooth in texture, and no evidence of stratification or lamination was found. Two or three thin layers of moderately coarse sand and several small pockets of sand were discovered. These pockets resembled the "sand boulders" sometimes found in clayey masses of glacial drift and may have been frozen or cemented when deposited. On the first trip I alighted from the train in a cut about fifty rods west of a long trestle two miles above Finmark and walked back along the track to the station. In this way I had a fine opportunity to examine the clay which is exposed in an almost continuous series of cuts in this interval. West of the trestle the clay appeared not to extend up more than 75 or 100 feet above the track, which is there about 100 feet above Finmark. (On C. P. R. profile Finmark is 1177 feet above sea level.) On account of recent caving, many of the clay surfaces in the cuts were comparatively fresh. In two places, one at the bottom of a section 25 feet deep, ditches had been dug out on that day. Weathered surfaces showed a distinct granular structure like the buckshot soil of the lower Mississippi, but no lamination. The grains or little blocks are fine at the top of the sections, a six-

teenth to an eighth of an inch in diameter, but increase in size with depth, reaching two or three inches diameter. Old surfaces in the cuts are crusted over, and have lost their brightness of color, becoming grayish red. Underneath this crust the clay is loosened up and is soft and spongy for six or eight inches. The fresh wet clay in the ditches has the quality and fineness of cocoa butter and its purity and homogeneous composition are quite remarkable.

The railroad follows the creek pretty closely, but is most of the time 30 to 90 feet above it. The creek flows rapidly in a rather narrow trench cut mostly in stony drift. It frequently encounters rock ledges, and is much choked with boulders. The bottom of the clay rests generally on grayish colored drift in the bank of the stream 10 to 30 or 40 feet above the water. The red bed appears originally to have covered the bottom of the valley and extended up its sloping sides for some distance. But its whole surface so far as seen is deeply gullied, forming a series of ridges sloping down from the valley sides toward the creek. The railway cuts across the lower ends of these ridges, and it was in these cuts that all the sections were seen. No part of the clay bed was seen which presented a plane surface free from gullies, but in one or two expanded parts of the valley the even tops of the ridges indicated the former existence of such a surface. The forms of the gullies suggest a considerable period of erosion. Their sides were no doubt steep bluffs at one time, but they have been worn down to gentler slopes and appear to have attained a stable form.

The Sunshine clays, as I call them, indicate an interesting incident of the glacial recession for this region, and they point clearly to a different history from that suggested by some of the early geologists who visited it. The clays themselves, while conspicuously lacking, so far as seen, in the horizontal laminations that generally mark fine deposits laid down in still water, are nevertheless, plainly enough, waterlaid. Their extreme fineness and perfect homogeneity with entire absence of boulders, pebbles, gravel, and even of sand or silt, with the exceptions mentioned above, puts them outside of the class of boulder clay or ice-laid drift. There are places in the sections where a glance from a passing train suggests boulders in the

clay. But on closer examination the boulders were all found to be projecting upward into the clay and really resting on the subjacent floor of drift or rock. In one case the clay was found abutting against an almost vertical bank of gravel which it had apparently once covered over entirely.

The red clay extends nearly to Nordland station but grows thinner toward Dexter and appears finally in only small patches here and there. Then comes a belt of sand and above that gravel. Bordering the edges of the marshes in some places north of Buda and south of Nordland there are small low fragmentary ridges of gravel suggesting shore structure. This part of the valley appeared to be too narrow, however, to have built beach ridges by wave action. If they are shore forms they are probably made by ice-jamming as is often seen on small lakes. The altitude of these surface gravels lying next above the red clays is about 1530 or 1540 feet above sea level. (930 or 940 feet above lake Superior.) I learned afterwards from Col. Dawson in Ottawa that there are old gravel terraces of shore origin on Dog lake towards the east (head of the Kaministiquia river) at about the same level.*

Nothing whatever was learned of the boundaries of this lake or the situation of its outlet. The contour of 1540 feet, however, would indicate a lake of considerable size, at least forty to fifty miles long and nearly as wide, and of very irregular shape, with an outlet most probably toward the southwest into the Rainy Lake valley. Its waters must have been held in by the ice-lobe that filled the Superior basin and stood as a wall across the eastward opening of the several valleys that converged to the lower Kaministiquia. The existence of a lake in this situation at this stage of the glacial retreat is quite contrary to the views of some glacialists, who would have the area of lake Kaministiquia still covered by the Kewatin ice-sheet.

Independently of these considerations I had concluded that the faint striæ on the north side of Mt. McKay indicated ice-motion from east to west, slightly north of west. But according to Dr. Bell Louis Agassiz observed striæ in a valley near Ft. William "running about due east."† Considering

*Possibly these are the same as those observed by Hind (1859) at Great Dog portage at 1435 feet.

†"Geology of Canada," 1863, p. 888.

what we now know of the ice-motion in the lake basins at the various stages, it is hard to see how there ever could have been motion toward the east at that place.

There is another area of red clay probably of the same kind and of the same or slightly earlier age in Minnesota west of the western extremity of lake Superior. It was probably laid down in the first glacial lake of the Superior basin, before the opening of the St. Croix outlet and hence before the time of lake Duluth. All these very red clays are evidently derived from the red rocks of the Nipigon series.*

Nipigon. In going by train from Port Arthur to Nipigon one sees a number of interesting evidences of the higher lake waters of the past. Sandy places and fragments of beaches are seen in several places. Prof. Lawson reports here a pitted terrace-plain at Mackenzie backed by sea-cliffs, altitude 497 feet, with another higher terrace. At Loon lake, 424 feet above lake Superior, sandy gravel overlies the stony clay in patches. At Pearl River, 246 feet above the lake, the surface is a mass of boulders and cobbles. East of the station there is a finely formed beach ridge of rather coarse gravel with well rounded pebbles. It runs for some distance nearly parallel with the track and appeared to spring from a rocky knob east of the station. It is cut on a long diagonal by the track just west of the rocks. Pebbles of bright red color and beautifully rounded are a large constituent. At a point about two miles east of Pearl River and 60 feet lower a narrow valley between bare hills is floored with greenish yellow silt and clay in finely laminated beds. In some places the fine sediments take on a reddish tinge. Farther east a broad plain of these sediments in beds with fine horizontal laminations, was crossed for several miles descending gradually from about 275 to 100 feet above the lake, and extending to Nipigon.

No ground favorable for the higher beaches appeared to exist near Nipigon station. Lawson reports the apparent crest

*In a letter to the author relating to the red clays, Dr. G. M. Dawson, director of the Canadian geological survey, very kindly gave the following references: "On the Fresh Water Glacial Drift of the Northwestern States," 1864, by C. Whittlesey, Smithsonian Cont., vol. xv. "Geology and Resources of the 49th Parallel," 1875, p. 213. Red clays of Minnesota are mentioned in some of the reports of that state. Those described here are also mentioned briefly by Dr. Bell in one of his early reports in the Canadian geological survey.

of a large terrace north of the station at 198 feet. The most important observations made here relate to the Nipissing beach and the character of the bed of the Nipigon river below this level. A start was made for lake Nipigon. but the great "Wiggins storm" of Sept. 22 to 24 found us about half way up the river and it was so violent that we were obliged to stop. So much of the brief time available for this trip was thus lost that we were obliged to turn back.

The Nipigon is a large river, and is in reality the upper St. Lawrence. Being the outlet of a large lake and having no large tributaries along its course, it would be expected that this river would be clear, and so it is in its upper half except for the stain of the muskeg. Its lower course, however, is quite remarkable for its character of newness. In this part the river is cutting its clay and silt banks and is quite muddy. At the upper end of the long portage, nearly half way up to lake Nipigon, the river is clear. The banks along the west side of the river above and along the shore of lake Jessie are of gravelly glacial drift. The long portage passes around extensive swift rapids, the lower part of which were run in a canoe on the return trip. The head of the rapids is probably at least 100 feet above lake Superior, but was not accurately measured. Camp Alexander is at the foot of the long rapids. The river here crosses a ledge of gneiss with no certain evidence of recent cutting or gorge making. The rock on the north side appears to be in rather loose blocks, but on the south side the ledge is solid and smooth, though uneven. It appeared to be a glaciated surface which had not been modified much by the river. Perhaps the river has cut the ledge down five or ten feet, certainly not more, and this was done by removing blocks that were probably loose to begin with.

From camp Alexander down to lake Helen, seven or eight miles, the river is nearly straight and flows with a current of two to four or five miles an hour in a comparatively narrow bed with low banks mostly of horizontal laminated clay and silt. Along the bank two or three feet under water the laminations were distinctly seen. Besides the finer laminæ, there appeared to be a harder layer every three or four inches. This projected a little over the softer layers next below, and these in turn rested on another harder layer. The bank under wa-

ter was nearly vertical and these layers gave it an appearance resembling the weather boarding of a frame house. Where the river turns into lake Helen there is a delta of considerable proportions, composed apparently entirely of sand and silt. It is only a little below the water surface and bears a growth of rushes. A well marked shore line on the east side of the lower end of lake Helen was not measured, but appeared to correspond closely in altitude with the Nipissing beach.

On leaving lake Helen the river flows rapidly for about a mile and makes a sigmoid curve, first to the east and then to the west. In this stretch the river is now cutting its banks rapidly. First from the head of the outlet to a point some distance below the railroad bridge it is cutting its east bank, then from there to the Hudson Bay Co's store it is cutting its west bank. At the time of my visit the river was unusually low, but the clear water that issued from lake Helen flowed past the store in a milky stream. Below the eastward curve and directly southward down the valley from the bridge there is an extensive modern delta much like that in lake Helen. By its great bend to the west the river avoids this and passes around its west side. The conditions presented by the river bed below lake Helen show the extreme recentness of its adjustment to its present level. At two higher levels in the vicinity of the railroad bridge there are terraces marking higher, wider channel floors, the first next west of the present bed is 20 to 30 feet above the present river and the next 50 to 60 feet. These two terraces evidently mark steps in the falling of the river from a higher level, apparently from the level of the Nipissing beach. Considering the fact that the barrier through which these old channels and also the present bed are cut is composed of soft clay, sand and silt with gravels above and the further fact that there is no other restricted passage on the course of the river from lake Helen to the open expanse of Nipigon bay, it seems clear that the terraces are related to former levels of lake Superior, higher than the present, but lower than the Nipissing beach; and the fresh condition of the present bed indicates very recent if not modern progressing relative elevation of this part of the coast. There are several faintly marked beaches on the slope between the station and the Hudson Bay Co's store. Lawson gives beach-

es at 61.3 feet, 28.4 feet and 13 feet. The exact correlation between the beaches and river terraces was not made out. It is evident from the eastward slope of the terraces at the bridge that the bed of the river has shifted continually eastward at that point during the falling stages.

East of Nipigon. For much of the way from Nipigon east to Winston's the railway lies on laminated silt beds, usually between 20 and 50 feet above the lake. At Gravel river there are extensive gravel beds near the station which appear to belong to a delta deposit made at a level considerably higher than the station which is 24 feet above the lake. They appeared to reach up at 40 or 50 feet above the station, but whether they belong to the Nipissing or a lower beach was not determined.

At a point about a mile west of Winston's the Nipissing beach appears in fine form and a great ballast pit has been opened in it, showing false bedding with eastward pitch and sand overlain by clean gravels. The gravels at Winston's station are at a higher level (210 feet or more, Lawson).

Schreiber. Lawson's observations at this point were verified and one additional terrace about ten feet higher than his highest was found. About a quarter of a mile northeast of the station, along the base of the hills where a small stream comes in, there is a small terrace which seems to be the modified delta of the stream. It is not wide, but is distributed some distance along the base of the hill. Its features suggest that it marks a former level of the lake at about 400 feet. A day was spent at Schreiber and an excursion was made up the flat little valley into the hills back of the town and up to the summit of those situated about two miles to the northeast, reaching a hight of 270 feet above the flat. No evidence of higher submergence was found, although the little valley should apparently have afforded as favorable an opportunity for a delta deposit above 400 feet as it did below. Down toward the lake an effort was made also to locate the Nipissing beach. But the brush was so thick along the trail followed that no satisfactory result was attained. There are several faint beaches covering an interval of a few yards below the highest beach, the most prominent being at about 345 feet. Below this are clay and silt beds 35 feet deep. Only

the upper beaches of Terrace bay were seen from the railroad track east of Schreiber.

Jackfish Bay. At this place and around the point about two miles east of Jackfish station, the old shore lines were found in magnificent form and all substantially as described by Lawson. The Nipissing beach appears here in one of its strongest types—a wide beach-plain with numerous beach ridges nearly at the same level. At Jackfish this long-lived lake shore is probably represented by Lawson's beach series between 85 and 110 feet above the lake, With the limited time at my disposal at this place I was unable to determine which beach stands for the upper mark of the Nipissing, but it seemed to lie between those at 103 and 110 feet. East of the point it was also difficult, from what I saw, to make out the exact upper level. Here, too, the beaches form a great ridged plain and appear to have been built almost wholly with material brought from the east where a great terrace at a higher level has been cut away at the Nipissing and lower levels. The most prominent ridge on the plain and forming the front edge of a slightly higher plain than that which lies in front of it, is about half way between the railway track and the cabin of Duncan MacIntyre. The higher ridges of this series are often bouldery, especially on their inner or rear sides. In one place the boulders are four to six inches in diameter and they lie nearly two feet deep with no filling between them. The beach-plain back of this prominent ridge is very ridgy and uneven, with some marked basins, almost a pitted plain in some places. This area is a counterpart of the Nipissing beach-plain at Rogers City, Michigan. Ten miles east of Jackfish there is a fine series of beaches belonging probably to the Nipissing. Three miles west of Caldwell there are beds of white silt capped with sand at about 250 feet above the lake.

Peninsula Harbor. This place is at the extreme northeast angle of lake Superior. Lawson visited it, but made no measurements, on account of fog. I found the top level about two and a half miles back from the lake on the south side of an embayment, the valley of a small river that enters the lake north of the station. The whole slope has been burned over and the features of the ground are not much hidden by later growth. The deposit which covers the slope appears to be

an old delta deposit of the Big Pic river which now enters the lake a few miles farther south. The highest mark of the ancient lake was found at about 410 feet above the lake. On the upper plain two or three pits were found, one 20 feet deep and about 200 feet in diameter. From the upper level down to the Nipissing beach-plain there are several terraces and ill-defined beach ridges, the most prominent one about 260 feet above the lake. Here again, the Nipissing beach appears as a great beach plain with many ridges at altitudes close to 110 or 115 feet (aneroid) above the lake. The material was apparently derived from the cutting of higher terraces towards the south and as they were built northward across the embayment they cut off a lower tract behind and formed a shallow marshy lake. The lake feeds a water tank for the railway, and the recently excavated trench for the laying of the pipe gives a characteristic exposure of beach material, sand and well-rounded pebbles. The edge of the plain back of the station and Mr. Mudge's house is bordered by a line of dunes from which a good view is had of the beach-plain back of them. The beaches below the Nipissing were not so clearly defined here, but one is fairly plain as a cut terrace at 40 or 45 feet. Back of the station the Nipissing beach-plain is about a mile and a quarter wide. Some of the ridges on the plain are sharply and beautifully developed in long parallel lines or curves. with lagoon hollows between.

East of Peninsula. The interval from Peninsula to Melgund was passed after dark, but a return trip was made next day from White river to the latter place. The lower beaches were not seen. But at a point two or three miles west of Cache Lake station, a sand plain like several others which mark the upper limit of submergence farther west was found backed by a sea-cliff, the altitude being approximately 420 to 425 feet. East of this along the course of the rapidly flowing White river to the hight of land near O'Brien and Amyot no sign of submergence was seen.

The great hills between White river and Grassett, forming the hight of land in that part and rising 200 to 300 feet above the general plain are mostly moraines of the ice-sheet and their forms seem to show that they were made by ice coming from the northeast. Their position suggests that they

may be partially interlobate in character, but distinct proof of this was not seen. The section in the great ballast pit at O'Brien shows glacio-fluvial action quite plainly.

Missanaibi. A canoe trip was made up Dog lake to the low col which forms a part of the hight of land. The trough in which Dog lake lies is one of those curious deep rock-walled valleys that cross the wide, low crest of the Laurentide ridge at many places. Into this valley near the head of Dog lake a small stream comes in from the eastern side and the present division of the waters is determined by the low broad delta which it has built since glacial times. The lake was at a very low stage at the time of my visit, but the crest of the delta was not over three or four feet above it and the creek on the north side flows away to Brunswick lake, Moose river and Hudson bay. At the high stage of springtime it is said the water sometimes flows northward over the delta. Much of the lake is deep. But there are boulderly narrows at several points that suggest either moraines or boulder spits made by the jamming of ice-floes. The boulders are mostly quite angular. The whole region is very boulderly, gneiss and granite predominating, and the boulders are almost all sharply angular. The shore of the lake is in a few places of solid rock, but nearly everywhere it is merely a mass of angular blocks with all finer material washed out by the waves. This valley may have been the course of glacial drainage for a brief period. But I saw no evidence of a great glacial or post-glacial stream, nothing resembling the old-channel characters seen in other places. No evidence of submergence was seen in this vicinity. Striæ at the station bear S. 38° W. (Mag.)

Summary and Conclusions. The higher beaches observed may be divided into two groups of localities, those clustered around Port Arthur and those near Jackfish. Not counting lake Kaministiquia, the upper limit of submergence in the first group is about 400 to 450 feet above the lake, while in the second group it is about 400 to 425 feet. Between the two groups there is an interval of about 70 miles in which high beaches have not yet been reported by anyone. (Highest reported by Lawson 360 feet at Mazokamah.) It might be supposed that the highest beach in the two groups is one continuous line, and it seems probable that this is the case, but further exploration

is needed to establish the connection. At Root river near Sault Ste. Marie Lawson's highest beach is the Algonquin, 414 feet above lake Superior. Between this place and the Jackfish group it seems hardly conceivable that there could have been a glacial or any other kind of barrier, and hence the inference seems clear that the upper beach of Jackfish group is the Algonquin. But there remains some uncertainty, of the identity of this beach in the west end of the Superior basin.

No attempt is made here to correlate the fragmentary intermediate beaches, those at horizons between the Algonquin and Nipissing. The last named beach, however, was clearly recognized at every place where the lower coast was examined. It is about 60 feet above the lake at Mt. McKay and Port Arthur, 90 feet at Nipigon station, 105 or 110 at Jackfish and two miles east of there and 110 to 115 at Peninsula Harbor. Its great length, compounded of many beach ridges forming beach-plains, gives it a physiographic prominence that is not equalled by any other shore line of the lake region.*

Several rather light but distinct beaches were found below the Nipissing, especially in the extreme north where the Nipissing beach is highest. The probable existence of at least one such beach was inferred from the observations of 1893 on the south Superior shore, and it was called the Sault beach because it appeared to hinge on the outlet at Sault Ste. Marie. On the south shore it is now all submerged and appears to lie about 50 feet below the Nipissing beach. It was estimated that it would be found somewhat more than 50 feet below the Nipissing along the north shore. The beach 28 feet above the lake at Nipigon, 33 feet at Jackfish and 40 to 45 feet at Peninsula seems to meet this expectation. The fragments so far found, however, are too few to warrant more than a provisional correlation.

Until the attainment of the results here presented the hypothesis entertained with most favor in explanation of the high shore lines of the Superior basin was that they were of marine origin. It was expected that the Algonquin beach would be found at a higher level than has been observed on the north shore and that there were straits northward to Hudson bay through the passes at Kenogami lake near Jackfish

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*AM. GEOL., Vol. xv, March 1895, pp. 165-167; May, 1895, p. 312.

and at Missanaibi. According to Lawson the altitude of the cols in these passes is 500 feet and 440 feet above the lake respectively. Measuring from Missanaibi station, however, the latter col proved, according to the Canadian Pacific railway profile, to be about 515 feet or 75 feet higher than the altitude given by Prof. Lawson. If the Algonquin plain is approximately even from Cache lake to Sault Ste. Marie this would leave the col at Missanaibi about 85 or 90 feet above the beach, and the col near Jackfish is nearly the same distance above the beach at that place. So the idea of straits to Hudson bay had to be given up and with it also the hypothesis of marine origin for the higher beaches. Subsequent observations in the Ottawa valley fully confirm the alternative hypothesis, namely, that the water which made the high shorelines of the northern lakes was held in place by a great ice-dam in the Ottawa valley, and that these lakes were incidental to the retreat of the ice-sheet.*

EDITORIAL COMMENT.

Light in the East.

The following extract is from the *Popular Science Monthly* of July:

Dr. Ebenezer Emmons and the Olenellus. During the geological survey of the state of New York which, commenced in 1836, was almost the first of the geological surveys that were entered upon and properly prosecuted in the United States, there was a marked difference of opinion between Prof. Ebenezer Emmons, of Williams College, who had charge of the portion of the survey that embraced the rocks of western Massachusetts and the upper waters of the Hudson, and his associate geologists, which finally terminated in a bitter personal antagonism and almost total ostracism of Dr. Emmons. The point at issue was mainly the relationship in respect to position and age of the rocks in question, especially those typified by the strata of Greylock mountain and the Hoosic valley. The position taken by the majority of the associate geologists on the survey was that the so-called Silurian system of rocks constituted the base of the fossiliferous rocks of New York, and inferentially of the whole country, and that the so-called "Potsdam sand-

*Am. Geol., vol. xvii, April 1896, pp. 253-257.
Am. Geol. vol. xviii, August 1896, pp. 108-120.
Inland Educator, Terre Haute, Ind. April 1896, pp. 138-145.
"Studies in Indiana Geography." Inland Publishing Co., Terre Haute, Ind. 1897, Chapter x, pp. 104-105.

stone" was the lowest fossiliferous member of this system, and in fact marked the dawn of life upon the planet. Dr. Emmons, on the contrary, claimed that beneath the oldest member of the Silurian system there was an older and extensively developed system of fossiliferous rocks to which he gave the name "Taconic," and exhibited an entirely new and characteristic fossil not before recognized or described and which received the name of "Olenellus." For all this Dr. Emmons received little or no credit, and among geologists was regarded as visionary and something of a humbug. But time at last has brought its revenges, for at the last meeting of the British Association for the Advancement of Science (Liverpool, September, 1896), Mr. J. E. Marr, F. R. S., president of the geological section, in an address reviewing the recent progress in this department of science, took occasion to speak of the "Olenellus," whose first discovery he attributed to Dr. Emmons, as characterizing a zone of life much older than the Silurian system, and as "furnishing us with a datum line from which we can work backward," and possibly prove the existence of a fauna of a date anterior to the formation of the Olenellus beds. So that Dr. Emmons, in place of being wrong in his observations and deductions, in 1845, [1844, N. H. W.] did really find the fossil he described, and rightly located the rock containing it in the geological horizon: and was thus entitled to take the lead at that time over all his American and European colleagues.

The fact that the discovery of this zone of life is now attributed to Dr. Emmons by a leading English geologist, when contrasting that zone with the Silurian system of Murchison, is gratifying to American geologists. It would be more gratifying if the legitimate and usual consequences of that priority were also accorded to Dr. Emmons, viz, that the name by which Dr. Emmons designated the rocks containing such fauna should be generally recognized and employed. There are but few instances in the records of science of more glaring and monstrous injustice than that which, with the connivance of American geologists, has deprived Emmons and American geology of the honor of giving name to that formation. It had no conflict with Cambrian, because that collided with Silurian, creating the great controversy with Murchison. It is only by shifting the significance of Cambrian, and applying it to lower strata that that term has acquired use in place of the term Taconic. Modern American geologists, under the guide, at first, of partisans against Emmons, have very largely fallen into this error. We look to see the correction come from the other side of the Atlantic, and chiefly from those countries which are not affected by the exclusion of either term.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geological Survey of Canada. Annual report, 1895. Dr. G. M. Dawson has issued his yearly report for 1895. It is a volume of more than a thousand pages and is accompanied with four maps of the Labrador peninsula. The first report is that of the director himself and contains a summary of the work. Among the items of interest the boring at Athabasca Landing is to be noted. It has now attained the depth of 1731 feet. The object of the work is to reach the basal sandstones of the Cretaceous series which at their outcrop westward are so heavily charged with bitumen as to be called the "tar-sands." These were looked for at a depth of 1200 to 1500 feet. But it has become evident that the overlying Cretaceous beds are thicker than at the outcrop and Dr. Dawson is now prepared to go to a depth of 2000 feet, though the drift is expected to reach the "tar-sands" at about 1800 feet. The great quantity of bituminous matter yielded by these strata is the reason for undertaking the work, and if it proves successful the advantages must be enormous in a country where fuel is scarce and dear.

A summary report on the season's work in British Columbia (chiefly on the mining regions) on Manitoba and Keewatin, on the better known but still only half explored eastern provinces of Ontario and Quebec, on the wilderness of the Labrador peninsula and on Nova Scotia comprise the director's report, which includes the labors of Messrs. Chalmer, Ells, Giroux, Fletcher, Tyrrell, McInnes, White, Ferrier, Lawson, Ingall, Low, and on paleontology by Messrs. Whiteaves and Ami.

In the Athabasca region Mr. Tyrrell reports above the Archean, the Huronian, Cambrian, Cretaceous and Pleistocene strata, the last three lying horizontal. Their thickness can consequently be ascertained only by indirect means. To the Cambrian sandstone and conglomerates he assigns a depth of about 400 feet. On the Cambrian area east of the Athabasca river no later rocks appear. "If any were deposited they have since been denuded away."

It is difficult to understand the following sentence after reading the above: "In the northwest portion of the district Devonian limestone was seen outcropping in the bottom of a small tributary of the Athabasca."

The Cretaceous rocks range from the Dakota sandstone up to the Pierre shales. Mr. Tyrrell adds: "After the close of the Cretaceous period a time of continental elevation set in which appears to have continued through the Tertiary to the present." Of the Pleistocene Mr. Tyrrell says: "The most conspicuous and interesting drift-hills occur in the basin of Cree lake, round Black lake and on the bank of Stone river. They are steep, narrow ridges parallel to the direction of glaciation with the sides joining on a crest that may be less than a yard wide

They average from a quarter of a mile to a mile in length and vary from 10 to 250 feet in hight."

Their shape, material and position lead the author "to believe that they were formed in narrow gorges in the ice-sheet into which streams flowing on the surface plunged and carried their load of detritus."

Dr. Adams presents a report on the geology and resources of that part of the Laurentian region lying north of the island of Montreal. He gives a detailed account of his petrographical work on the minerals of the gneiss, with illustrations of the way in which they have suffered, and on the severe earth-strains to which they have been subjected since their formation. Crystals of quartz, feldspar, etc., have been crushed or flattened down into thin laminæ and "augen gneiss" in many cases developed. A note is added on some of the anorthosites of other parts of Canada and foreign countries for comparison with the Morin anorthosites and others from Canada. These rocks occur in immense masses in Canada, the United States, Norway, Russia and Egypt.

A second report by the same author deals with the smelting of the titaniferous iron ore according to a process advocated by A. J. Rossi of New York. These ores have of late years gone out of favor after a time of great popularity, but Dr. Adams seems to think that they are now unjustly neglected and should be used in Canada as they are in some other countries. He reprints a paper by Mr. Rossi read before the Amer. Institute of Mining Engineers in February, 1893, giving details of the mode of treating these ores.

Mr. Low reports on the Labrador peninsula the results of four years' labor. Much of it is not geological and is therefore not relevant here. He says: "The peninsula of Labrador is a high rolling plateau, which rises somewhat abruptly, within a few miles of the coast, to a hight of 1500 to 2000 feet. The interior is undulating with ridges of low, rounded hills that seldom rise more than 500 feet above the general level. This, near the central watershed, varies from 1000 to 1800 feet, which may be taken as the general hight of the interior of the peninsula. The highest part of the main interior mass is near the high granite area between the headwaters of the Peribouka, Manicuagan and Outardes rivers, flowing into the St. Lawrence; the East Main and Big rivers, flowing into Hudson bay, and the Koksoak, flowing into Ungava bay. Its general elevation exceeds 2000 feet. The interior is almost flat so that in an area of 200,000 square miles there is not a difference of more than 300 or 400 feet. It is covered with myriads of lakes occupying at least one-fourth of the total area. Some exceed 500 square miles. Many are mere ponds.

"The channels of most of the rivers of Labrador are of very ancient origin, apparently dating back to a period before the deposition of the Cambrian rocks, and have been mainly formed by normal erosion."

Full details of the geography compose the remainder of the report, and that of Mr. Hoffman, which follows, gives all particulars of the chemical and mineralogical work done in the laboratory at Ottawa during the year. E. W. C.

Extrusive and intrusive igneous rocks as products of magmatic differentiation. J. P. IDDINGS. (Quart. Jour. Geol. Soc., vol. LII (1896) pp. 606-617). In a recent important publication (Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Südtyrol) Prof. W. C. Brögger expressed dissent from some of the inferences of Prof. Iddings from his study of the rocks of Electric peak and Sepulchre mountain in the Yellowstone park, and in this paper Prof. Iddings explains more fully the relations of those eruptions to the whole series of which they are but a part. Brögger's chief criticism, or difference of opinion, was based on the idea that the extruded rocks examined by Iddings were of a limited amount and extent, and that the primary differentiations of the deep-seated magma should be determined by a study of deep-seated and not of effusive rocks. Iddings sketches the volcanic history of the great floods of Montana, Idaho and Wyoming, as follows:

At the end of Cretaceous time there were great orographic movements by which the region was profoundly faulted and dislocated. Volcanic action began at this time, and fragments of igneous rocks are included in the sandstones immediately overlying the coal-bearing Laramie, which witnessed the close of the long period of quiet which had prevailed during Paleozoic and Mesozoic times in that region. After this upheaval there was extensive surface denudation whereby the sedimentary strata were entirely removed from off the underlying crystalline schists. Into these disturbed strata the igneous material was forced, and upon the uneven surface of the country it was spread out, covering crystalline schists in one place, and upturned sandstones and limestones in another. In most cases the character of the eruptions was extremely violent. At first they were largely explosive, shattering the surface rocks, whether gneiss or limestone, and scattering them broadcast to form the first layer of tuff-breccia, or to be ultimately mingled with the fragments of lava. The explosive character prevailed until a great accumulation of tuff-breccia formed a chain of lofty volcanoes comparable with those of the Andes in size as well as in the nature of their material. The later eruptions from these volcanoes were quieter outflows of lava, which probably took place after position of the volcanic conduits had become more stationary. Erosion having carried away the upper parts of these great cones, the remaining portions are almost equally made up of breccia, in places 4000 feet thick.

The last of the great eruptions were equally violent, though of a different kind. They were gigantic fissure-eruptions that flooded the region west of the chain of denuded volcanoes with massive streams of lava that rose high up on the flanks of the surrounding mountains, and then flowed toward the southwest, leaving when cooled and after erosion had somewhat reduced the surface of the stream, a vast sheet of lava at least 1000 feet thick in most places, and over 2000 feet thick in some parts. This was followed by other outflows from fissures that flooded the region for hundreds of miles to the southwest and west and closed the period of activity. Within the Yellowstone park the earliest breccias were accumulated in Eocene time, and the great bulk of the Absa-

roka volcanoes in Miocene, while the great fissure eruptions just mentioned took place in the Pliocene.

A map accompanies this sketch showing the surface distribution of these three parts. 1st the andesyte, 2nd the rhyolite and 3rd the basalt. The volume of igneous rock emptied to form the andesytes of the Absaroka range and the surrounding areas is estimated, within the bounds of reason, at 4000 cubic miles. The floods of rhyolite that escaped at the time of the great fissure eruptions now cover an area 50 miles from east to west, and 90 miles from north to south, and it continues further, but is covered by later basalt. The volume is much more than 400 cubic miles. The basalt which issued later from vents or fissures further west, must have a volume of at least 700 cubic miles. These vast extrusions manifest fixed variations in acidity, establishing, in the view of Prof. Iddings, the general law that first come eruptions of medium acidity (andesyte) followed by very acid (rhyolite) and then by very basic (basalt), the latter two being closely associated and representing the complementary extremes of differentiation. He concludes: "It was upon evidence of this order that I ventured to enunciate the principle that in a region of eruptive activity the succession of eruptions commences in general with magmas representing a mean composition and ends with those of extreme composition." N. H. W.

On the southern Devonian formation. H. S. WILLIAMS. (Amer. Jour. Sci., (4) III, 393-403.) In this Prof. Williams has attempted to restore some of the features of the Devonian geography of the eastern part of this continent. Every such contribution is welcome to the student of paleozoic geology, and Prof. Williams has made so extensive and continued a study of the subject, especially in its palæontologic aspects that whatever he puts forth deserves careful consideration.

In grappling with these problems the author frankly confesses the immense difficulty which some of them present. We owe to him very largely the indications of what seems to be at least a probable opinion that a radical change occurred in the mid-Devonian life of the Appalachian region by the immigration of a fauna hitherto existing in the northwest. But as with others it is not easy for Prof. Williams to indicate where lay the barrier whose removal allowed them passage. That the Wisconsin peninsula extended far enough southward to bar the way seems very difficult of admission and yet no more plausible theory can be at present put forward.

But the problem of the great black shale is the one to which Prof. Williams has chiefly turned his attention in the tract before us, and of this he says frankly: "I have been unable to arrive at any satisfactory explanation of it."

A recent study of this shale in Virginia, Tennessee and Kentucky, where in some cases it is of unusual thickness, added nothing to the scanty fauna. But Prof. Williams has been led by this work to venture the opinion that the material of the black shale was not derived from the east but from the western side of the channel or gulf of Appalachia.

Prof. Williams' attempt to explain the Oriskany sandstone also, while removing one of the difficulties connected with it, appears to introduce another. Attributing the Oriskany sediments to a subsidence of land to the northeastward, opening communication with the ocean in that direction, he would thereby account for the purity of the Oriskany fauna and sediment in the northeast corner of the basin. But when we review the Silurian history we can scarcely doubt that this passage was continuously open long before. The existence of Lower Helderberg limestone and of deposits, probably Corniferous, along the whole line from New York to the northeast at intervals, and the close resemblance between the Upper Silurian fauna of the two sides of the Atlantic almost compel us to admit the existence of free water communication with the Atlantic of that day, and apparently preclude our attributing the formation of the northeastern channel to the Oriskany sub-era.

Prof. Williams concludes by stating in words several geological and paleontological propositions whose truth cannot be doubted but which are not always kept in clear view by writers on these difficult problems of American geology. E. W. C.

The Newark System. Report of progress. HENRY B. KÜMMEL. (From the annual report of the State Geologist of New Jersey for 1896. Trenton.) These rocks in New Jersey are divided into three parts, the Stockton, the Lockatong and the Brunswick, in ascending order, not including the traps. These divisions are based on lithological differences although these differences are not abruptly separable.

The Stockton series embraces (*a*) coarse, more or less disintegrated arkose conglomerates: (*b*) yellow, micaceous feldspathic sandstone: (*c*) brown, red sandstones or freestones, and (*d*) soft red, argillaceous shales. These parts are interbedded and many times repeated, but the characteristic beds are the arkose conglomerates.

The Lockatong series, next above the Stockton, consists of hard dark colored shales and flagstones, sometimes carbonaceous. They are sometimes hard, massive, black and purplish-black argillytes which break sharply in any direction with a conchoidal fracture. The flagstones are dark gray and green.

The Brunswick series consists essentially of shales, with a few sandstone layers. They are prevailingly red, but vary locally to purple, green, yellow and black.

These three series are quite distinct toward the southeast, but they lose to some extent their distinctive characters when traced toward the northwest border.

The thickness of these parts is expressed, after careful calculations and estimates, as follows:

Stockton	4,700 feet
Lockatong	3,600 feet
Brunswick	12,000 feet
Total	20,300 feet

The traps are both intrusive and extrusive, a fact that shows a co-

temporary state of volcanic activity during the Newark system. In contact with the fragmental strata the traps have in some places caused a generation of epidote and tourmaline and a general hardening: and sometimes a nodular and spotted aspect, as if crystallization had begun to act at innumerable points.

This report is to be followed by a final memoir when the whole field has been studied. N. H. W.

Observations on Popocatepetl and Ixtaccihuatl, with a review of the geographic and geologic features of the mountains. OLIVER G. FARRINGTON. (Field Columbian Museum. Geol. Series, vol. I. no. 2, 1897.) Mr. Farrington has succeeded in adding much to our knowledge of these mountains, as well as condensing most of what was before known from earlier explorers. The description is accompanied by several photographic plates of the crater of Popocatepetl and of the glacier named Porfirio Dias by Heilprin, of which latter he gives the first adequate description. He found that this glacier, like many others of North America, is in a state of retreat. Popocatepetl is an extinct volcano, but Prof. Farrington is inclined to believe that Ixtaccihuatl gave forth only fissure flows of lava. This opinion is based on the homogeneous and compact nature of the igneous rock of which the mountain is so largely composed, and the elongated form and direction of the valley in which the glacier lies, and on the absence of any known centre of volcanic activity. Of the two it is the older mountain, and is supposed to be about a thousand feet less high than Popocatepetl. The rock in both is essentially andesyte but with variations of texture. However, according to the Mexican geologists Aguilera and Ordoñez the earliest eruptions of Popocatepetl were basic basalts, with olivine, the order of the variation in mineralogical composition being different from that found by Iddings in Electric peak. N. H. W.

The fuller's earth of South Dakota. HEINRICH REIS. (Trans. Am. Inst. Min. Eng., July, 1897.) This clarifying and decolorizing agent has not been known in this country until within the past two years, when it was announced from Florida by the United States Geological Survey. Mr. Reis describes it from Fairburn, Custer county, and from Argyle and Minnekahta, South Dakota, giving several analyses. The deposits are large and are likely to take the place in this country entirely of that imported hitherto from England. N. H. W.

Twenty-first annual report of the department of geology and natural resources, Indiana, W. S. BLATCHLEY, state geologist, Indianapolis, 1897. Mr. Blatchley has chapters as follows: The natural resources of Indiana: The petroleum industry in Indiana: Indiana caves and their fauna: A catalogue of the uncultivated ferns and fern allies and the flowering plants of Vigo county, Indiana. Other contributors to this report are: W. A. Noyes, Composition of Indiana coals: Hans Daden, Some notes on the Black slate or Genessee shale of New Albany, Ind.: August F. Foerste, Report on the geology of the middle and upper Silurian rocks of Clark, Jefferson, Ripley, Jennings and southern

Decatur counties; T. C. Hopkins and C. E. Liebenthal, The Bedford oolitic limestone of Indiana; J. C. Leach, Report of the state natural gas inspector; Robert Fisher, Report of the state inspector of mines: C. F. Hall, Report of the state inspector of oils; J. T. Scovell, Geology of Vigo county.

This volume is well printed and well illustrated and contains valuable scientific and economic reports, and is a credit to the State of Indiana.

N. H. W.

The Building Materials of Pennsylvania. I. Brownstones, T. C. HOPKINS, Assist. professor of economic geology in the Pennsylvania State college. (Appendix to the Annual Report of the State college, 1896.) There is no better way than this, in which the state universities, especially those which have agricultural and mechanical departments or experimental stations, can serve the State and demonstrate their usefulness. At the same time such investigations, directed by scientists, are sure to make important contributions to geology. Further a purely economic report, in the hands of the ordinary statistician, lacks authority and influence as it lacks a scientific basis. It may be a question whether it is not too much the custom to confine these institutions to practical agriculture and such chemical researches as grow out of it. A few of them have instituted quasi-geological surveys as a basis on which to exploit all other economic, and especially agricultural researches. It is to be hoped, as it seems probable, that the authorities of the Pennsylvania State college will continue this series of economical reports. N. H. W.

Development and mode of growth of Diplograptus, McCoy, R. RUEDEMANN. (Report of the State Geologist [New York] for 1894.) This paper gives the results of a careful study of graptolites found in eastern New York in the Lower Silurian. The delicate, often linear, stipes which are the commonest form in which these fossils appear, were found by Hall to radiate from a centre, or central disc, branching sometimes into spreading fronds with many radii. The special object of later observers has been to elucidate the structure and functions of this disc. Within this horny disc are globular vesicles which are sometimes eight in number. Each vesicle contains a capsule varying from oval to club-shaped, with a firm test whose interior offered no obstruction to the entrance of sediment. These vesicles also contain the so-called "siculæ." It was obvious that the vesicles are reproductive organs, and comparable to those of the living Sertularians. The author gives in detail, with references to figures drawn from specimens, the process of development of *Diplograptus pristis*. N. H. W.

Artesian wells in southern and northern New Jersey and in the Cretaceous strata of Long Island. LEWIS WOOLMAN. (From the report of the state geologist of New Jersey for 1896.) This report consists principally of the records of deposits in the areas mentioned. Deep wells in New Jersey draw water from six principal water horizons, partly in the Cretaceous and partly in the Miocene. N. H. W.

Abram Gesner; A review of his scientific work, G. F. MATTHEW. (Bulletin xv, Nat. Hist. Soc. New Brunswick, 1897.) This is a companion and supplement to Bulletin No. xiv which contains a sketch of the life and character of Gesner by his son, W. G. Gesner of New York. These together amply set forth and will serve to perpetuate the important work that was performed in the extreme eastern provinces of Canada by this geological pioneer. This work is not a mere list of the published books and papers of Gesner, but Dr. Matthew has added many discussions and comparisons, with critical comments, apropos of the cotemporary literature. Not the least interesting is the history of the Graywacke system of New Brunswick, the lower part of which in his last report (1843) Dr. Gesner classed as Cambrian on account of the scarcity of organic remains. Gesner's geological map of a part of New Brunswick is reproduced in black characters. N. H. W.

The Cretaceous clay marl exposure at Cliffwood, N. Y. ARTHUR HOLLICK. (Trans. N. Y. Acad. Sci., XVI, Jan. 1897.) Some of the results of the assiduous study of Mr. Hollick on the Cretaceous deposits of the Atlantic coast are here given. To the flora which has already been described Mr. Hollick adds a number of new species. N. H. W.

PERSONAL AND SCIENTIFIC NEWS.

ARCTIC EXPLORATION. Lieut. Peary this year takes several parties to Greenland for scientific purposes, landing them at some points selected by themselves, while he goes farther north to initiate plans for a grand expedition next year in search of the pole by way of cape Sabine, and to procure the great mass of native iron which it was found impossible to handle last year. The parties who accompany this expedition are as follows: Prof. C. H. Hitchcock and a number of assistants who will spend the summer in the region of Ivigut for the purpose of glacial investigation and for the study of ruins of the old Norse colonies; R. W. Porter who goes to Baffin land at Forbisher strait, who will remain for a year's exploration of the interior north of Forbisher bay and west of Cumberland sound; Charles Schuchert and David White for the study of the fossil localities of the Noursoak peninsula, and for the collection of fossils, a region renowned for the fossil flora described by Heer; and others not for geological purposes.

The geological society of America has taken favorable action, at the instigation of Lieut. Peary, looking to concerted efforts for the more systematic survey of the northern coasts of North America.

PROF. E. H. WILLIAMS, Jr., is making a survey of the "Kansan" drift in the vicinity of Warren, Pa., a continuation of his investigations begun in 1892.

JOHNS HOPKINS UNIVERSITY. GEO. B. SHATTUCK, Ph. D., recently fellow in geology, has been appointed assistant in geology. CLEVELAND ABBE, Jr., has been appointed fellow in geology.

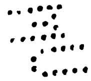
YALE UNIVERSITY. DR. CHAS. E. BEECHER has been made full professor of historical geology in the University. DR. L. V. PIRSSON has been made full professor of physical geology in the Scientific School. Both gentlemen have been put on the Governing Board of the Sheffield Scientific School.

APPLETONS' POPULAR SCIENCE MONTHLY for June contains an account, accompanied by portraits of several geologists, of the coming meeting of the International Congress of Geologists at St. Petersburg. There is also a sketch of Richard Owen written by Pres. D. S. Jordan.

THE AMERICAN MICROSCOPICAL SOCIETY will hold its next meeting at Toledo, first week in August, guest of the Toledo Microscopical Society. The president is Dr. E. W. Claypole, Akron, Ohio, and the secretary is Dr. Wm. Krauss, Buffalo, New York.

THE SCHOOL OF MINES OF PENNSYLVANIA STATE COLLEGE is endeavoring to supplement to some extent the State geological Survey reports by publishing papers on the economic products of the state. Prof. T. C. Hopkins of that school prepared last year a report on the brownstones of the state and this summer is at work on the clays of the west part of the state. They expect to continue the work on other economic subjects so far as the time and means permit.

GEOLOGICAL SURVEY OF WEST VIRGINIA. A bill providing for a geological survey of this state was passed by the legislature at its last session. It puts the survey under a commission made up of the governor, treasurer, president of the West Virginia University, president of the State Board of Agriculture, and the director of the West Virginia Agricultural Experiment Station, who serve without compensation, except actual expenses. They appoint as superintendent of the survey a geologist of reputation, and such assistants as they deem necessary. The objects of the survey are: an examination of the geological formation of the state, with special reference to economic products; an examination of the soils and their adaptability to particular crops; an examination of forests; a study of the physical features of the state with reference to their practical bearing upon occupations, industrial development and material prosperity of the people; the preparation of special geological and economic maps to illustrate the resources of the state, and the preparation of special reports on the geology and state resources. (*Engineering and Mining Journal.*)



THE CORNELL GLACIER FROM MT. SCHURMAN SHOWING A MEDIAL MORAINE EXTENDING TOWARD THE SEA.

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THE MARGIN OF THE CORNELL GLACIER.*

RALPH S. TARR, Ithaca, N. Y.

(Plates VI, VII, VIII, IX, X, XI, XII.)

CONTENTS.

*The studies upon which this paper is based were carried on by the Cornell party, which accompanied the Peary expedition in the summer of 1896, and spent a month on the Upper Nugsuak peninsula, in Lat. 74 deg., 10 to 15 min. Aside from the writer, the members of this party were professor A. C. Gill and Messrs. T. L. Watson, J. A. Bonsteel, E. M. Kindle, and J. O. Martin. To all of these I am greatly indebted for aid in the work, and I wish also to express my indebtedness to Lieut. Peary and also to Mr. E. G. Wyckoff who furnished the money for the expedition.

Nature of the Study. Professors Chamberlin and Salisbury have recently* described very fully the conditions along the margin of numerous valley glaciers, and valley glacier tongues of the Greenland ice cap, notably those in the Inglefield gulf region. They have also described some of the features along the margin of the main ice cap. It seems unnecessary to duplicate this description by the statement of observations of similar phenomena made upon the smaller glaciers of the Upper Nugsuak peninsula region. However, some features seen by us differ from those described by these authors, and some of the characters described by them were not observed. It therefore seems important to state in some detail the conditions found along the margin of this part of the ice cap.

Aside from the study of small glaciers and of the evidence of former glaciation in the Upper Nugsuak peninsula, considerable time was spent in the examination of the large glacier which terminates in the sea at the head of the deep fjord on the south side of this peninsula. The name Cornell glacier was given to this hitherto unnamed ice tongue, whose source of supply is the great Greenland ice cap. It comes down to the sea in a broad valley, which at a distance of five miles from the front is bounded by mountainous valley walls not less than twenty miles apart. As it proceeds toward the sea the glacier narrows between the mountainous valley sides, and when it ends in the fjord the distance from the north to the south margin is seven or eight miles. It has not a continuous sea face, but is interrupted by a partial nunatak, whose sea front is about 1.8 miles. This nunatak called mount Hope divides the glacier into two unequal parts, the northern arm being about 1.4 miles long and the southern arm 4.6 miles.† There is, therefore, a total sea frontage of about six miles, and a curved line parallel to the front of the glacier and one or two miles from the sea, is nine or ten miles long.

The northern margin of this peninsula, for a distance of about ten miles, and the contact with the nunatak, mount Hope, were studied in some detail, and the surface of the front of the ice was also examined. With Messrs. Martin and

*Jour. Geol.

†These measurements were obtained from a map, for the preparation of which I am indebted to Mr. J. A. Bonsteel of the Cornell party.

Bonsteel I made a journey over the ice to a nunatak which rises above the glacier at a distance of eight or ten miles from its margin. This nunatak, named mount Schurman,* was ascended, and its contact examined. We therefore obtained a rather clear idea of the conditions existing on and at the margin of a part of the Greenland ice cap, and also of a single great glacier tongue extending from it into the sea.

Rock Fragments on the Ice Surface. Excepting at its base, where it comes in contact with the moraine and the nunataks, the ice, so far as seen, was absolutely free of all debris excepting of two kinds. Near the sea, and in fact as far as we went out upon the ice, to a distance of six or eight miles from the terminus, the glacier surface was pitted by the dust wells which have frequently been described. These were of impalpable dust, evidently blown from the land. Professor Gill has examined some which was collected at a distance of about three miles from the nearest land, and under the microscope discovered distinct fragments of recognizable minerals. The larger pieces are biotite mica, but there are also smaller fragments of epidote, plagioclase, feldspar and quartz. In the specimen examined the largest pieces of mica measured one-sixth of a millimeter. This dust rested in wells of water whose depth was usually not greater than eight or nine inches, though in some cases as much as 15 or 18 inches. In diameter the wells varied from one-eighth of an inch to several feet. The total amount of this dust in an acre of ice would amount to only a few pounds.

The second class of debris was found in only one place, on the seaward or down stream side of the mount Schurman nunatak. (Plate VI.) This was a moraine of large rock fragments, with a considerable admixture of clay, derived from the two lateral moraines of mount Schurman. The clay element was of minor importance, and at a distance of a mile from the nunatak had almost entirely disappeared, being carried away by water, and removed by the good sized streams which flowed over the ice surface parallel to, and along the side of the moraine. As the distance increased the moraine became more and more attenuated, until finally there was only a narrow band of rock, resting as a mere film on the ice sur-

*After president J. G. Schurman of Cornell University.

face. Here not only the clay, but all excepting the larger fragments had been carried away along the smooth stream bed. So complete is the destruction of the moraine by this means and by the crevassing of the ice surface further down, that we were unable to say where the moraine reached the fjord. The sea front of the glacier showed no signs of the presence of any medial moraine, and hence we conclude that it has all found its way to the bottom of the glacier.

Drainage on the Ice Surface. There was distinct drainage on the ice surface. Innumerable tiny streams occurred, and either cascaded into the crevasses or flowed rapidly down over the margin of the glacier. Small lakes also exist in the irregularities of the ice surface, and one that was seen had an area of about an eighth of a mile by 75 yards. Its waters were clear and its bottom entirely free from sediment.

The large stream which flowed parallel to the mount Schurman medial moraine received its supply in great part from the marginal drainage along the boundary of this nunatak. We followed it for more than a mile and found it flowing in a valley, often bounded by a steep wall rising to the hight of 15 or 20 feet. The slope was rapid, and its width varied from a few yards to ten or fifteen. In no place was it narrow enough to be crossed without wading. Finally, about a mile from the nunatak, the stream turned abruptly at right angles, crossing the moraine and flowing toward the south, in a cañon with walls twenty or thirty feet high. It was impossible to follow this stream further, but from the fact that it was flowing toward a much crevassed part of the glacier, we had no doubt that it soon disappeared beneath the surface of the ice.

Nature of the Ice Surface. The surface of the glacier presented two opposite types of outline, the smooth, hard and only slightly crevassed surface, over which travel was moderately easy, and certain very much crevassed areas which could not be traversed. Of course there was every gradation between these extremes. The crevassed portion was greatly roughened by melting, so that it became a maze of deep cracks with intermediate hills of clear, slippery ice. Attempts to penetrate this were in every case given up after a journey of a few dozen yards. The crevassed areas are of two kinds, those located on the surface of the ice where it swells upward

into domes, on the sites of buried hills—unborn nunataks—and those where the motion was rapid. The crevassed domes varied in diameter but were surrounded by smooth areas so that the crevassing was apparently due to the cause which produced the local upswelling.

The more general crevassing, included under the second division, was confined to the distinct valley portions of the glacier, where the movement was more rapid. Practically the entire area of each glacier tongue, from the land boundary on either side, was thus crevassed; and the irregularity increased perceptibly toward the central and lower portions. In reality, along this part of the ice the smooth traversible areas were the exception; and in our journey to mount Schurman we were obliged to look carefully to see whether we could pass out to the nunatak over the ice. There was but one feasible route, unless we should make a detour from a distant point and approach the nunatak from the rear by a journey of 25 or 30 miles. This smooth area lay between the two nunataks, and hence in the line of slight motion. From the fact that in this place the ice surface was distinctly higher than on either side in the two arms of the Cornell glacier, we also concluded that this was a ridge over the buried highland in the underlying land. In other places it was also found that the ice cap could be reached most easily from the divide areas between two valley tongues. This was notably the case between the Cornell glacier and the Wyckoff glacier, which is the next valley tongue on the northern side of the one which we chiefly studied.

Ice Motion. So marked was the irregularity of the ice surface that it became evident upon first inspection, and certain after some attempts had been made, that it would be impossible to go out upon either the north or the south arm of the Cornell glacier to a sufficient distance to obtain the real average rate of motion. With little time at our command, and many new features to study, we decided that the attempt to measure the rate of movement of the glacier promised less results than a study of other features. Hence no actual measurements were made; but from the amount of ice coming from the front of the glacier it was evident that the rate was considerably less than in some glaciers hitherto measured on this

coast, such for instance as the Upernavik glacier fifty or seventy-five miles south of this one. No large icebergs came from the front in the two or three weeks that we were camped within sight of the glacier. However, numerous icebergs of medium size were sent off, and innumerable small fragments were constantly floating away from the glacier. During the time that we saw the ice front in intimate detail, its outline did not change in any of its larger features, though there were many changes in minor details.

Sea Margin. The sea front of the two arms of the Cornell glacier is a solid wall of ice (Plate VII), undercut somewhat at the water level, and from this rising in most cases as a perpendicular precipice to a hight of over 200 feet above the sea and in the higher places to an elevation of 300 feet. The crest of this sea wall forms a ragged sky line, as the crests and pinnacles are outlined against the sky, and it is cracked by crevasses in such a way, that every now and then pieces of great or small size are tumbling off, sending reports through the air and waves across the fjord. The birth of an iceberg was the most impressive sight among all the wonders of my Arctic journey.

This ice wall was of marble whiteness throughout its entire extent. Not only was there no sign of debris on the ice surface, but none was revealed in the 200 or 300 feet of a point which rises above the sea, nor was there either lamination or stratification. It was a solid wall which in fracture resembled a find-grained dolomitic limestone which has no particles discoverable by the eye. In color it was of dazzling marble whiteness. So far as the sea end furnished evidence there might have been no debris and no differential movement that would cause banding. That this conclusion is not warranted is plainly shown when an iceberg comes from the front, and in its turning reveals the bands of dirt in the lower ice. Not only was there no englacial or superglacial moraine, but there were no streams on or in the ice at its margin. Hence the theory of englacial or superglacial origin of certain kinds of glacial deposits receives no support from this study.

The Land Margin—Outline. The ice cap in this region comes in contact with the land, coinciding closely with the irregularities of the land itself. If there is a valley a tongue

THE ICE-WALL.

enters it, provided the elevation and slope permit; if a precipitous indentation of the land occurs, the ice margin reaches further than on the point projecting toward the ice. Coming to a nunatak the ice rises against the land on the eastern side, then sweeps around it, the two arms meeting at a very much lower level at the western base. On the eastern side of the partial nunatak mount Hope the ice surface is about 1060 feet above the sea, and the nunatak reaches an elevation only 390 feet higher, or 1450 feet, while on the western or seaward face of this nunatak, the mountain rises 1450 feet above sea level, and from 1250 to 1300 feet above the ice surface. The same feature is seen around mount Schurman. There the ice surface is 1750 feet above the sea on the eastern side, and only 1350 feet a mile further west at the western base of the mountain. Hence this nunatak, whose elevation is 2210 feet, rises nearly 1000 feet above the western ice surface and only 460 feet above the eastern. About three miles west of this is a nunatak just peeping through the ice stream of the south Cornell glacier. It is so overridden on the eastern side that it cannot be seen from that direction; but from the west it is plainly visible.

Land Face. The margin of the ice cap or the glacier in contact with the peninsula and the nunatak, is prevailingly characterized by a moderate slope. (Fig. 1, plate VIII). In this it differs radically from the conditions described by Chamberlin and Salisbury for the glaciers north of cape York. There a moderate slope of the ice margin was an exception, in some cases to be explained by the presence of snowbanks at the base; here it is the rule, and is the natural glacier face. In all I followed its margin for no less than fifteen miles, and in this distance traveled many miles on the actual ice slope. Again and again I passed from the ice top to the land. Here a vertical slope was the exception. Oftentimes the lower debris zone of the glacier presented a moderate slope and the clear upper ice a precipitous face; but it was never necessary to go far to find an area in which ascent to the ice surface was easy.

Debris in the Ice. Along this margin I found that Chamberlin and Salisbury have described a distinct separation between the debris-free upper ice and debris-filled lower layers

distinctly stratified, (Fig. 2, plate VIII); but unlike them I found no contortion of the laminæ. The banding was wonderfully even, and the layers parallel, being deflected only by irregularities of the bed. Nor were there any upturned layers such as those recently described by professor Salisbury.* I found none of the surface moraines to which Lieut. Peary had called my attention, and which professor Salisbury has recently described and offered as an explanation the theory that they are due to the upturned edges of the debris-filled laminæ.† The amount of debris in the ice along the margin was slight, and the fragments varied in size from large boulders to clay bands.

Movement. The movement of this part of the ice along the land margin was continuous. In other words, although there was much melting along the glacier terminus, the ice cap does not move out to the point where melting exceeds supply, but goes off toward the land, where considerable is melted, and is then deflected by the valley walls and turned off toward the valley tongues. In the case of the Cornell glacier there is this ice drainage along the valley walls toward the more restricted fjord; and as the ice is turned by the land, its velocity becomes higher, because more and more is supplied to the narrow exit. Therefore not only in the narrow valley tongues, but even along the land margin, the supply of glacier ice from the interior is destroyed only in small degree by melting and mainly by breaking off in the sea and floating away. Around the nunataks the conditions are somewhat different; here the ice comes upon the land in a direct way, piles up against the stoss or east side, and then divides, flowing away along the side of the nunatak.

The motion along the margin of the ice cap is therefore different from place to place and will vary with the thickness of the ice covering. While the glacier front is standing at a certain place, the direction of ice movement in the glacier valley tongue will be directly outward along the axis of the valley; but a few miles distant, on the valley sides, the movement will be diagonally along the valley walls toward the axis. With a thicker ice covering, overspreading all the land,

*Jour. Geol.

†Jour. Geol.

FIG. 1.—NORMAL SLOPE OF THE ICE CAP AT THE LAND MARGIN NEAR THE CORNELL GLACIER.

FIG. 2.—STEEPLY SLOPING LAND MARGIN OF THE ICE CAP NEAR THE CORNELL GLACIER.

the advance would be directly outward from the interior; and hence in the two stages the striæ would vary in direction in the same place. With this deflection in ice movement there is of course also a deflection in transportation. Materials brought from the interior nearly to the land margin instead of being deposited on the land may move along its edge down toward, and even into the sea.

Attack on the Nunatak. Around the nunatak the ice shows very distinctly the difference in attack on the stoss and lee sides. Coming against the eastern face of mount Schurman, the ice piles up on the back and then divides; and it is evident that all along the eastern, northern, and southern sides of the nunatak the ice is scouring with rapidity. But on the west side the currents unite at a distance of two or three hundred yards below the end of the nunatak, and there is no indication that the union of these two tongues is made sufficiently early to scour the western mountain face. There is a stagnant block of ice between the mountain and the united currents that come around the nunatak. That this effect has been noticeable throughout the history of mount Schurman is plainly shown by the topography. The entire mountain has recently been submerged beneath the glacier; yet the western side is so precipitous that standing on the margin one looks down a nearly vertical precipice upon the ice 1000 feet below; and if one should fall from the edge of this he would go at least 200 feet without striking the rock wall. Upon this margin, although recently glaciated, there is almost no glacial scouring. The much higher Devil's Thumb shows that the same conditions once existed there. The eastern side is distinctly glaciated; but a stone dropped from the western face falls a thousand feet before striking rock, and this face is greatly roughened.*

Moraine at the Ice Terminus.—In the Sea. What there is in the sea at the base of the glacier we had no means of telling; but I doubt very much if extensive moraines are accumulating there. Practically all of the debris brought by the ice is distributed in the lower layers of the glacier. There is none to be washed down from the top and front, and thus to accumulate in the sea. All must come from the bottom,

*For this observation I am indebted to Mr. J. O. Martin.

and this part of the ice is subjected to melting only by contact with water whose temperature never rises much above the freezing point. Hence great quantities of the lower debris cannot drop off in the neighborhood of the glacier. Every now and then an iceberg passes off from this glacier front, and the moraine which it contains passes out into the fjord, to be distributed over its bed, or in the more distant seas. It therefore seems that along the sea front the morainic accumulation must be slight. With a distinct surface moraine the case would be quite different.

On the Land. Along the land margin there is a nearly continuous morainic ridge parallel to the ice front. (Fig. 2, Plate VIII, and Figs. 1 and 2, Plate IX.) It usually rests at the base of the ice foot, and is sometimes a part of this foot, where debris has accumulated and protected the ice beneath from the warmth of the sun, causing this part of the glacier to rise as a ridge. Frequently, however, the moraine ridge is well separated from the ice margin, and sometimes there are several parallel ridges from which the ice front has successively withdrawn. Recent withdrawal is indicated by this ridge now separated from the ice.

To me it was extremely disappointing to find nothing that closely resembled the great moraines of the United States. In topographic outline the deposit along the ice edge on the land was more like an esker than a moraine. It was a ridge quite like a lateral moraine, and some of the larger moraine ridges extend as long embankments, rising from ten to twenty feet, with a width of thirty or forty feet across the base. Here and there the combination of several ridges gives the hummocky outline of our moraines, but these were distinctly exceptional. (Plate IX, Fig. 2.) The reason for this peculiarity of outline is evidently the direction of ice motion. Along the ice margin the movement is diagonal to the land; hence, while there is a movement toward the narrow valley glacier, there is also some material brought to the edge and left there by melting.

An increase in the supply would cause less topographic change on the land margin than in the sea face. In this region of great topographic diversity there is little chance of an oscillation on the front. The forward movement would override the moraine ridges and carry the material down toward

FIG. 1.—RIDGE-LIKE MORAINE AT THE LAND MARGIN OF CORNELL GLACIER.

FIG. 2.—HUMMOCKY MORAINE ON THE MARGIN OF CORNELL GLACIER.

the sea, instead of pushing them to a new margin. The reason for the ridge form is that debris comes to the ice ledge, and. loosened by melting, rolls to the bottom, accumulating there. In most cases the moraine was evidently much less thick than it appeared to be because of the ice foot below; but some ridges twelve to fifteen feet in hight, were evidently entirely composed of rock fragments because separated from the ice by an interval in some cases as great as 150 feet. The ridge form is necessary because the ice along the land advances and retreats only very slightly. The only way in which an extensive deposit of hummocky moraine could be formed would be for the ice to stay nearly in one place for a long time. If the glacier retreats, the debris from the ice is distributed as a thin covering; if it advance the moraine is carried away toward the sea.

The material brought by the glacier to this terminus was very stony, and hence the surface features are those of very rocky moraines. They are often piles of boulders with very little clay, though at times the clay element formed one-half the bulk of the moraine. The rocks were frequently rounded and scratched like ordinary ice transported fragments. Among these boulders gneiss predominated, but porphyritic granite, slate, and quartzite, derived from some hidden areas beyond the ice margin, are abundant, and the size of the blocks varies up to ten or fifteen tons.

In some places along the land margin the moraine on the border of the ice is increased in bulk by the addition of debris falling from the land. But this is rare, and is found only where the ice movement is such as to press it against precipitous hills. Around the nunataks this condition is not uncommon, for there the rapid glacier movement presses the ice against the land. At mount Schurman there are two such bands, one on either side, caused partly by glacial debris and partly by masses falling from the cliffs; and the union of these two bands forms the medial moraine described above. Professor Barton showed me exactly such a moraine around the base of the Umenak mountain near the town of Umenak. It had been gathered there at a time when the glacier had passed out into the Umenak fjord, and the mountain had risen as a nunatak above the valley, in exactly the same way that mount Schurman now rises above the Cornell glacier.

Ice Margin Drainage. The land front of the glacier is a slope, varying in steepness, and forming one face of a valley whose other wall is the land, sometimes having a gentle slope but usually a precipitous hill side. In the valley thus formed there is a marginal drainage, (Plate X) with a water supply furnished mainly from the ice. Numerous tiny streams flow from the glacier top, cascading down the slope and uniting with the marginal stream. No single case of a subglacial stream emerging from beneath the ice was found. The melting was entirely surface and marginal, though along the sea front it is perfectly certain that there is subglacial drainage. The surface melting of the crevassed glacier forms streams which disappear into the ice, and which come out somewhere below sea level; but we were not successful in finding out where these emerged.

In its passage down the valley, between the ice and the land, the marginal stream finally enters the sea. During its passage it now and then encounters tongues of ice, and for a distance flows along them, and finally beneath them, where the glacier edge rests against a moraine, or the rock of the land. Again it falls over a rock ledge as a cascade, or even a grand waterfall; and every here and there it is dammed to form a marginal lake. (Plate XI.) Dozens of these, great and small, were seen along the margin; and they varied in size from tiny pools to ponds half a mile in length, and 200 to 300 yards in width.

Since the water of the marginal streams is everywhere milky with sediment, these lakes are receiving quantities of muddy deposits, and in them tiny deltas are being built. (Fig. 1, Plate XII.) Where the lake waters bathed the ice front little icebergs are coming off, in exactly the same way as in the fjord at the glacier front, and these are bearing out into the lake large rock fragments which are being strewn over the bottom or on the shores. Also at the base of the ice cliffs, as well as on some of the deltas formed by rapidly flowing streams, pebbles and boulders are being mixed with the clay.

Nearly every lake shows signs of alteration in level resulting from the change in outflow either to some point beneath the ice, when the lake may be entirely drained, or to some lower outlet for the lake opened by a change in the ice front,

NORTH ARM OF CORNELL GLACIER.

or by the down cutting of the stream bed where it is eating its way through a morainic dam. The different elevations are plainly evident from the absence of lichens on the rocks. the clay clinging to the rocky shores, and the beach terraces along the old shore lines. In one case, at the western end of mount Schurman, a lake of this type, with a depth of at least 100 feet has recently been drained. Where these extinct lake beds exist one sees revealed an expanse of muddy bottom with scattered blocks of rock. No chance was found of determining the depth of these clay beds, but in some cases they were evidently several feet deep, perhaps even several scores of feet.

In the deposits now being made along the margin of this glacier there were two extremes, the bouldery material and the clay beds. No sand or gravel deposits were seen. Hence here is another of the many differences between the present results of the Greenland glaciation. and the more ancient deposits that were made by the American glacier.

Morainic Complexity. By the study of the moraines and marginal lakes along the ice front, one sees enough to help him to a satisfactory conception of the manner of formation of the irregular moraines in the United States, where the drift supply was greater and the oscillation of the ice front more easily possible. Co-operating with the normal dragging of materials to the margin, and with some possible shoving of materials at the end, accompanied by the accumulation of talus deposits at the base of the glacier front, there was the action of streams over the ice surface, and possibly from beneath, and the presence of the lakes and frequently changing marginal drainage. Lakes appear and disappear, being caused by conditions now in part absent. With a complex interaction of these various causes the topography and structure of the American moraine seems easily possible to one who has traveled along the edge of the Greenland ice cap. All that is needed is a little imagination which will permit the ice to change its front more frequently and to bring a greater supply of debris.

As has been described above, the land moraine of this Greenland glacier is generally a ridge; but sometimes it becomes a series of choppy hills, quite like those of the American moraines, due to the presence of several ridges with diff-

erent axes, and formed by a slightly different rate of supply. Another supposed cause for irregularity of morainic topography was also seen illustrated. In the valley tongue of the south Cornell glacier, on the southern side of mount Hope, the terminus is in a marginal lake whose waters are milky with sediment furnished from the glacier. Like the balance of the glacier, this tongue is retreating. So recently has it withdrawn to a notable degree, that at a distance of twenty or thirty yards from the margin there are two large blocks of ice stranded in the lake, each piece having an area of perhaps half an acre. These are grounded in the water, and are partly or entirely cut off from the glacier. In any event they are separated from it by the lake water. Hence they are being surrounded by sediment, and as they melt still further, their tops will come beneath the lake, and they will be buried beneath the sediment. Even now they are evidently weighed down by the load of clay, for they do not rise more than a few feet above the lake surface, and not so high as they would need to rise if they were afloat. When finally the lake disappears, and the ice withdraws, we shall have a pair of typical kettle holes.

Variation in Lower Ice Currents. Along the glacier margin, we may often see the effect of the irregularities of the bottom upon the movement of the ice. Ledges and small hills are often present beneath the glacier, and their influence is to deflect the lower layers by their tiny irregularities. The lowest ice rests on the surface, occupying its depressions; but the layers above are curved only in accord with the *general* surface. In other words, the irregular surface is made more regular by the nearly stagnant bottom ice, which fills the depressions, and raises the lee side of the elevation toward the top of the higher part. This raises the irregular surface into a form having approximately the outline of the general upper levels. The ice arches over the irregular land, making curves, which are plainly seen by the arch of the debris layers, whose form is that of a generalized dome of a regular form. (Fig. 2, Plate XII.) This curve frequently simulates the drumlinoid curve. Layers once disturbed and raised do not continue at this level in the ice, but return to approximately the same elevation as that where they started. Here

MARGINAL LAKE, CORNELL GLACIER.

is seen the reason for the formation of roches moutonées forms; some areas are scoured more than others, and there is a gradual reduction to a generalized surface because the depressions are protected by more nearly stagnant ice, while the projections are worn down toward the curve of average outline of the irregularity.

Variations in the Direction of Ice Movement. The ice sheet, burying all land so that no sign of it is found on the ice top, as is the case in the interior of Greenland, must move with moderate directness and uniformity. Perhaps there is some deflection by topographic irregularities of great size, but such variation would be the same in direction so long as the thickness of the ice remains constant. For instance, if a part of the present irregular border of Greenland were overridden by the ice sheet the general direction would be westward, notwithstanding peninsulas and mountain peaks, which, however, might deflect the ice slightly from the general direction. Any considerable deflection could not be caused, for the land irregularities are less in importance than the force which is pushing the ice onward.

When such a land is being abandoned by the ice sheet, quite different conditions are introduced. At first the mountain peaks begin to appear as nunataks, first, merely checking the ice movement and making it nearly stagnant on top, while the glacier moves around the sides, deflected possibly many degrees from the original course. Later, by rising above the ice, and dividing it into two streams, which may possibly meet on the downstream side, or if the terminus ends in the sea failing to join, a similar deflection is caused. Where it comes in contact with the land there may be decided deflection of the ice currents, possibly toward a valley tongue, as frequently is the case with the ice near the margin of the Cornell glacier. Near the margin there may be a very decided deflection of currents, even in neighboring parts of the glacier, and at the *exact terminus* the deflection may be even greater.

A tongue of ice, led away by some favorably situated valley, will go in whatever direction the valley leads; and one of the most astonishing results that I obtained from my study of the ice margin, was the discovery of the remarkable manner in which the ice is thus deflected. Even a tiny depression

may suffice to lead away a tongue of the ice cap. On the southern side of mount Hope such a valley glacier, projecting from the south Cornell glacier, moves at right angles to the main axis of the ice, then turns again, until at its end the current is actually back toward the direction from which the ice came. Here debris brought from the east turns northward and finally back a short distance toward its source in the east.

Later, if the land is high, the continental glacier becomes transformed locally to smaller snow fields, or ice caps, and valley glaciers. Such is the present condition of the Upper Nugsuak peninsula, and doubtless other parts of the Greenland coast.* Then the glaciers may begin to move back toward the direction from which the earliest ice cap came, and the boulders may be carried back toward their sources. It is possible that some of the gneiss boulders mentioned by professor Chamberlain as occurring at the terminus of the Blasedale glacier of Disco island may have begun such a journey eastward toward their original source.† In the Upper Nugsuak there is certainly this movement. When we are considering the distribution of drift in the United States we must certainly take into account this fact, that ice near the terminus of a great glacier is decidedly deflected, and that the currents in different stages may be not merely at right angles, but even parallel to, and back toward some previous position.

Drift on the Upper Nugsuak Peninsula. As much as three-fourths or even four-fifths of the Upper Nugsuak peninsula is either bare rock or talus deposit. The barrenness of drift is remarkable. In protected places, on slopes and in narrow valleys, there are till beds, and now and then there are moraines at the margins or ends of the valleys; but elsewhere there is bed rock. No stratified deposits of drift were found on the peninsula. Indeed the place where drift is most abundant is exactly along the glacier margin. At first I thought this indicated a longer stand of the ice at this point: but very soon the true explanation was seen to be *removal* rather than failure to deposit. At best the Greenland glacier is not greatly drift laden, but the amount in all parts of the lower ice that was visible would even now furnish at least a thin film over the land, if the ice should melt.

*See Tarr, AM. GEOL., vol. XIX, April, 1897, pp. 262-267.
†Jour. Geol.

FIG. 1.—DELTA IN A MARGINAL LAKE, CORNELL GLACIER.

FIG. 2.—ARCHING OF ICE LAYERS BY IRREGULARITIES IN THE BED.

On the steep hill sides it has been washed off from the rock, so long smoothed by the ice and made slippery by the melting of snow and frost in the summer. In the torrents of early summer most of it has left its place, and the hill sides have been left nearly bare.* The proof of this is found in the peculiar distribution of the boulders. It was noticed that on the hill sides, and even on many of the hill tops, the only remains of glacial deposits were boulders, most of which either rested on pebbles, or on a flat face, either of their own or of the bed rock. The characteristic condition of the boulder was perched on two or three pebbles, and so raised above the bed rock that one could look beneath the boulder to points beyond. Thus perched in a stable position, some of the boulders have remained, while the small beds of clay and pebbles, and the less favorably placed boulders, have gone away, leaving these as monuments testifying to the former presence of at least some drift.

Comparison of Greenland and American Glacial Deposits. While it is true that from the Greenland glacier were obtained many hints concerning the conditions existing during the American glaciation, it is equally true that the conditions in the two places were widely different. In the first place the topography of Greenland is unlike that in most of the United States, finding its nearest analogue in the Adirondacks and northern New England region. Then too, the greatest activity of the Greenland glacier is in the valley glacier tongues, which end in the sea, while for America the glacier end was mainly on the land. Where the glacier ends against the land, the cause for this terminus is only partly that of melting. Much of the material brought toward the land margin eventually goes into the neighboring sea, either in streams or in the ice directly, as this is deflected by the land.

Morever the amount of debris carried by the American glacier was very much in excess of that now being transported by the Greenland ice sheet. This may be due to the greater hardness of the Greenland rock, though this is not greater than in parts of New England. The conditions on Labrador and Baffin land are more nearly like those on the margin of Greenland than the United States. I believe this is because

*Tarr, Am. Geol., vol. xix, 1897, p. 131.

the part now exposed on the Greenland coast is comparable rather with Labrador than with the United States. I mean to say that during its greatest extension the Greenland glacier removed the decayed rock materials, as well as much fresh bed rock, from this region and deposited these fragments in Baffin bay, the bed of which would therefore contain the deposits, whose position compares with the marginal glacial accumulations of the United States. Whether this is the case or not, the present Greenland glacier is certainly dealing with bare and hard rock, while the American glacier had an easier task, and hence obtained a greater load.

Another difference must be recognized in the climate. At best only a small amount of melting can take place every year near the margin of the Greenland glacier, while practically none occurs at a distance of a score or two of miles from the edge. Hence there will not be great floods in this land, such as those which occurred in America.

Hence in America with more material to deposit, a rapid withdrawal due to hurried melting, a more level land surface over which to spread, and materials which must in most parts find a resting place on the land, there were great and complex glacial deposits, whereas on the Greenland margin the glacial deposits are relatively more simple. Nevertheless the student of glacial geology cannot visit the margin of the great ice cap without gaining much inspiration, valuable knowledge and important hints to aid him in his study of the work done by the great extinct American ice sheet.

NOTE ON HYPERSTHENE-ANDESITE FROM MT. EDGECUMBE, ALASKA.

By H. P. Cushing, Cleveland, Ohio.

In September, 1892, during an enforced stay of a week at Sitka, Dr. H. F. Reid ascended Mt. Edgecumbe and brought away with him a few small specimens of lava from the crater which were given to the writer for examination. It was the intention to publish this note along with a paper by Dr. Reid setting forth the results of his observations. These however he desires to withhold pending another visit to the mountain, but has sent the following letter for publication as a preface:

MAY 18TH, 1897.

Mt. Edgcumbe is a volcanic cone situated on Krusov island, 13 miles west of Sitka, Alaska. It has quite regular outlines and its altitude is given in the U. S. Coast and Geodetic Survey maps as 2855 feet. Its lower slopes are thickly wooded but the upper part of the mountain is quite bare. The rim of the crater is a broad oval of something more than a thousand yards along its longest diameter. There is a difference of about 400 feet in the hight of the lowest part of the rim (on the southern side) and the highest point (on the northwestern side). The bottom of the crater is also oval with a slightly sloping floor about 230 feet below the lowest part of the rim. Sections of former lava flows are visible on the steepest parts of the inner wall of the crater. Lava flows exposed on the southeastern shore of the island still preserve in places their original surface. Everything shows that the volcano has not long been extinct, but it probably has not been in eruption since the discovery of Alaska by the Russians, 150 years ago.

Mist was driving over the mountain when I was on the summit, and I did not have a good view of the region surrounding the mountain, but Prof. Wm. Libbey has given a short description of this region in the Bull. Am. Geog. Soc. 1889, pp. 279-288.

All the specimens I sent were gathered in the crater or on the rim in September, 1892.

HARRY FIELDING REID.

The specimens are of a quite normal hypersthene-augite-andesite, the interest attaching to them being on account of their geographical location and of their similarity to the volcanics to the southward along the same volcanic belt. They range from compact dark gray rocks dotted with small feldspar and pyroxene phenocrysts to a nearly black pitchstone and to a light colored, frothy pumice.

Mineralogical composition. Plagioclase, hypersthene, augite and magnetite, in order of abundance, make up the slides. Two generations are invariably present. In two cases aggregates similar to those which result from the corrosion of hornblende, were noted, but no trace of the original mineral remains and the boundaries are indefinite.

The plagioclase phenocrysts are stout prisms bounded by many planes, often forming complicated intergrowths, with pronounced zonal structure and dearth of twinning. Extinction angles averaging 28° on opposite sides of the trimming plane show them to belong to the bytownite-anorthite series. They abound in inclusions of glass, pyroxene and magnetite. The zonal structure is of both types, in some cases a regular

increase in acidity from the center to the periphery, in others a succession of basic and more acid layers. This latter is the more common of the two.

. In most of the slides the hypersthene preponderates over the augite. Its microscopic characters are as usual. As is the rule in andesites the pleochroism is rather faint for this mineral, with very slight difference between **a** and **b**. Parallel growths with augite are of frequent occurrence, the brachypinacoid of the hypersthene in contact with the orthopinacoid of the augite. Both magnetite and glass occur as inclusions, but are infrequent.

The augite phenocrysts are of a pale yellowish-green color, intermediate between the pale greenish and pale greenish-yellow of the hypersthene. A very slight pleochroism is apparent, the yellowish tinge being somewhat more pronounced parallel to **a**. The extinction angle is 48°. Inclusions are the same as in hypersthene.

The groundmass. The eleven specimens show considerable variation in the texture and structure of the groundmass. This is also probably true of the chemical composition, the material furnished being insufficient for analytical purposes. In five specimens there is little or no glass and one of them is quite coarsely crystalline, made up of short, thick bytownite crystals and prisms of augite and hypersthene, the whole thickly set with magnetite dust. The remainder are similar except for the smaller size of the crystals.

Of the remaining six specimens two show ordinary hyalopilitic structure, while in the other four (the pumices and pitchstone) the groundmass is wholly glassy.

The specimens also range from a rock with basalt-like groundmass, with much pyroxene and magnetite, and feldspars in the labradorite-bytownite series, to a rock with trachytic groundmass, the feldspar laths composing it belonging to the oligoclase-andesine series and the pyroxenes only occurring as phenocrysts.

Enclosures. The slide from specimen 8 shows a small enclosure of fresh diabase indicating its presence somewhere in the path of the lava.

Two other slides show enclosures of small size made up of

colorless glass set with augite prisms, the augite being precisely similar to that of the enclosing andesite and reaching the size of the ordinary phenocrysts of that mineral.

Freshness of the material. For the most part the specimens are of perfectly fresh rock. As they consist of small pieces picked up on the mountain this fact has significance as indicating the comparative recency of the outflow. But three specimens show any sign of decay. Two of the pieces of pumice have their glass reddened by oxidation of the ferrous oxide, and the pitchstone has suffered slightly from the same cause. Specimen 8 likely represents an older flow, as its pyroxene has suffered some decomposition. The smaller crystals of that mineral have been wholly, and the larger externally, converted into the reddish-brown mineral which is so frequently produced by the decomposition of pyroxene in such rocks.

Conclusion. The recent lava of Bogosloff Id., Alaska has been shown by Mr. J. S. Diller to be hornblende-andesite.* With this exception no andesite has been reported from Alaska as far as the writer is aware. Its occurrence here is therefore of interest, especially in connection with the occurrence of similar lava throughout the whole extent of the American Sierra belt.

SOME GEOLOGICAL CAUSES OF THE SCENERY OF YELLOWSTONE NATIONAL PARK.

By A. R. Crook, Evanston, Ill.

For most of our knowledge of the underlying causes of the scenery of the Yellowstone National park we are indebted to Holmes, Hague, Iddings, Weed, and others of the United States geological survey. The results of their work should be in the hands of every traveller to the region, since the pleasure of the trip is greatly enhanced by some knowledge of the cause of the phenomena and by some idea of the forces which have produced the mountains, hills, and valleys, the heat of the region, the geysers, and the wonderful coloring. A student of creation here finds splendid illustration of the dynamics of mountain building, of the formation and metamorphosis of

*Science, Jan. 1885, p. 66.

rocks, of thermal and chemical action, of erosion and glaciation.

The park is situated in the northwestern corner of Wyoming, halfway between St. Paul and the Pacific—a thousand miles from both. It embraces more than thirty-five hundred square miles—more land than is contained in Delaware and Rhode Island together. Its average elevation is eight thousand feet above sea level and it is thus one of the domes of the United States. It is surrounded by mountains. On the southwest are the Tetons, containing some of the grandest and highest peaks of the Rockies, rising nearly seven thousand feet above lakes at their base, and composed of Archæan gneisses and schists flanked by Palæozoic sediments on the north. On the southeast border the Wind River mountains which are composed largely of Cretaceous sandstone that protrudes in the park above the lava flows. The Absarokas, whose culminating peaks are compact andesite and andesite breccia, extend along the east; and the Snowy mountains present their granitic and schistose faces along the north side. On the west for twenty miles stretch the Gallatin mountains which rise from two to four thousand feet above the park. Moisture-laden winds entering the park strike against the sides of the mountains and precipitate their snow and rain. Consequently the rainfall is much greater and the temperature much lower in the park than in any other place in that part of the country. It measures at Mammoth Hot Springs twenty-five inches yearly. Halleck gauged the Yellowstone and Lamar, the Firehole and Gibbon, and estimated the Gallatin, and found that the minimum discharge would equal that of a river five feet deep and one hundred feet wide flowing at the rate of three miles per hour. This large amount of water explains the presence of the Yellowstone lake which is the largest body of water at that elevation known (being one hundred forty square miles in extent) and partly accounts for the rapid erosion by the rivers. The temperature being lowered by the evaporation of so much water explains the prodigious chiselling of the region by frost. While the country east of the park was suffering under the terrible heat of August 1896, we in the park were breaking the ice in our water pails.

Thus the topography of the country influences the rainfall and the rainfall influences the topography.

The character of the country is due in the next place to the fact that it is new. This is evident even to those who are not geologists. Nearly all the other parts of the United States were completed before the Yellowstone region began to take its present form. The Gallatins, the first range to be seen upon entering the park, furnish a good example of the history of the region. Upon Archæan granites, schists, and gneisses which subsequent operations have exposed to view, were deposited the quartzites, sandstones and limestones of the Silurian. These were followed, in a slow, quiet, uneventful manner by the schists, clays, sandstones, and limestone of the Carboniferous, Jura-Trias, and the Cretaceous. At different places in the park the siliceous and shaly limestones of the lower, middle, and upper Cambrian, the characteristic rocks of the Devonian, and the typical subdivisions of the Cretaceous —the Dakota, Colorado, Montana, and Laramie—are exposed. These rocks were laid down conformably. Then came a period of intense disturbance. The peaceful course of events was changed. The sluggish, phlegmatic plains were shaken, upturned, and made into heroic mountains. The southern end of the Gallatin mountains was raised. A sharp fold occurred between Electric peak and Cinnabar mountain. The axis of the general fold trends northwest and southeast. This elevation and folding of the rock masses caused the layers to crack and fault—to slip past each other like the river ice at spring thawing—so that the resulting mountains were filled with crevices and passage ways leading to great depths. Some portions of the earth mass underneath relieved of pressure expanded, passing from potential to actual liquidity. This molten material was crowded up through the passageways filling them, crowding between the layers of fissile strata forming lacolites and sills, and pouring out upon the surface in enormous floods. There were definite, well marked periods of cracking and flooding.

What the novel is to human life the geological story is to geological occurrence. In an hour's reading the novel presents the events of a life time, but human experience teaches the proper interpretation. A geological description presents in a few minutes the events of a myriad of years and human experience is unable to disclose the proper perspective. The

best aid to a conception of geological time is geological field work. One who sees erosion going on in the park at a slow rate and measures the work already completed has a time measure. When he notices the different great systems of sedimentary rock and the many varieties of eruptive rocks, he obtains a series of objects that measure back in sharply defined units to the remote millions—fading away in the distance like a series of telegraph poles.

Thus to properly understand the causes of the present appearance of the park it must be kept in mind that there have been definite periods in its making. After the first long period was completed by profound disturbance and a series of eruptions and long continued erosion in the Eocene, there came in Miocene time three eruptions of well defined character. The first was an eruption of moderately acid rock called "andesite." It is a light colored rock of various shades. Its principal bulk or groundmass is glassy to cryptocrystalline and contains phenocrysts of three minerals, viz., a soda lime feldspar (andesine or labradorite), hornblende or augite, and biotite. This rock forms the tops of many of the mountains and is called the scenery rock. After a long period of cooling, erosion and cracking, came an eruption of an acid rock, rhyolite. It also is a rock of varied colors and texture, varying from white to black and from glassy to cryptocrystalline. Its phenocrysts however are chiefly a soda-potash feldspar and quartz. It covered the whole park, filling all the valleys and rising two thousand feet upon the sides of the mountains. About the only rock that the tourist meets in the park is rhyolite.

The eruption of rhyolite was followed by one of a dark basic rock, or basalt. It is a dark-colored glassy or completely crystalline rock with groundmass of labradorite and phenocrysts of lime feldspar (anorthite) and augite and olivine.

The order in which these rocks were erupted is instructive. Prof. Iddings calls attention to the fact that first there came forth a rock of mixed chemical composition. After the molten mass or magma in the earth had time to differentiate, the basic or heavy material sank and the acidic rhyolite arose near to the surface. The next faulting forced this top layer out

and finally the deep-lying basalt was pressed through the dykes.

Nine-tenths of the park is composed of volcanic rocks and the scenery must necessarily be different from that of regions composed of sedimentary rocks. The Appalachian system or that of the Alps, from which the majority of our people obtain their ideas of mountain scenery, contain no rock like this. The volcanic rocks of the park show no peaks, for example, like those in the Alps where stratified and schistose rocks have been folded into sharp anticlines that by wearing away have left jagged peaks steep on all sides. The volcanic rocks having no pronounced parallel structure and never having been subjected to great pressure and contortion wear away on the surface in rounded forms and where carved by streams show pinnacles and crags whose mass is horizontal. Thus we see that the scenery of the park is the result of the material used in its construction as well as the result of its newness and its surroundings. Now we may further see how it is the result of the destructive agents at work there.

The periods of eruption were followed by an ice age in which glaciers covered the whole of the park and scoured it from one end to the other. As the volcanic rocks were still hot in places the melting of the encroaching ice would be very rapid and the resulting floods enormous and very powerful in erosion. One glacier moved west from the Absarokas and another east from the Gallatins. They met in the valley of the Gardiner and moved north, carving out the valley of the Yellowstone along a line of faulting. Evidences of the glaciation are seen in the valleys which are strewn with scratched and rounded bowlders that have been carried long distances from their source.

But a far more powerful and deep working agent than the ice is the chemical action which, as the result of water, heat, and subterranean gases united, has showed its power far and wide in an astonishing degree. Geysers and hot springs, extensive decomposition and deposition and the wonderful colors of the region are illustrations.

In no other place in the world can geysers be seen to such advantage. Those in Iceland, New Zealand and California are neither so accessible nor beautiful. Geysers, boiling springs,

hot springs, paint pots, and mud puffs—all different stages of the same phenomena—represent the mighty conflict of meteoric waters and volcanic fires. As Bunsen explained, water collecting in a tube, which is very deep and very hot at the bottom, is heated far above the boiling point, since it is under pressure. Circulation setting in, hot portions of the water reach a point at which the expansive force of the steam exceeds the confining power of the pressure and flash into steam. One explosion creates a vacuum; the vacuum, relief of pressure at greater depths. This in turn allows another explosion and so on until equilibrium is restored. If the tube is shallow or heat applied at the sides or the heat is not very great instead of a geyser there occurs a boiling spring. Less heat would produce a hot pot; less water a mud pot. If the mud is colored it is called a paint pot.

The springs differ not only in size, shape, temperature, and amount of water but also in the nature of the substances dissolved in them. Ordinary water has the power of dissolving a large number of mineral substances. The number is enlarged and the power of the action is increased if the water is intensely heated. The presence of various gases and chemicals in the water gives another great increase in its power of decomposition. In the park the water is abundant, highly heated and full of powerful corrosives. The deposition of dissolved materials around the mouth of the springs is enormous.

There are three principal kinds of springs, acid, calcareous, and alkaline-siliceous. The acid springs (which are the least important) deposit alum, sulphur, soluble salts of iron, and some of them contain hydrochloric acid (Norris Basin). They do not affect the scenery materially.

Far more important are the calcareous springs like those of the Mammoth Hot Springs basin. They contain chiefly calcium carbonate, and also calcium sulphate, magnesium sulphate, calcium chloride, alumina and silica. The deposits cover three square miles with several hundred feet of travertine. The source of this lime is interesting. It is doubtless derived from the Cretaceous limestones which underlie the rhyolite, filling up the basin.

The most interesting and important of all the springs are the alkaline-siliceous for geysers occur only with them. They

contain principally silica, calcium carbonate, sodium borate, sodium arsenate, and sodium chloride. One-third to one-fifth of all their content however is silica. It amounts to about six-tenths grammes to a thousand of water. It is derived from the decomposition of the acid rhyolite. This shows how dependent the peculiarities of the park are upon the material out of which it is constructed. For if the underlying rock were limestone the material, though soluble, would not form geysers. If it were sandstone it would be practically insoluble because of absence of alkalies to aid in the decomposition. The deposit which is called siliceous sinter consists mainly of silica with varying amounts of water. If it is glassy it is called rhyolite. If it contains less than six per cent of water it is called pealite; if from six to thirteen per cent, geyserite; if seventy-five per cent, viandite, an unstable leathery substance which crumbles when dry. The geyserite is deposited over an enormous space. In thirty years not more than one inch is formed. The conduit of Old Faithful is at least seventy feet deep. This would indicate that for twenty-five thousand years the deposit has been taking place.

The cause of the deposition has long been a puzzle. It was thought that the cooling of the water would furnish an explanation. But demijohns of water standing two years gave no precipitate. However when the water was frozen precipitation did take place. It is now known that the deposits are due to three causes, a chemical, a physical, and a biological. The chemical is shown by the fact that the amounts of alkaline chlorides and carbonates present influence deposition; the physical, by the fact that evaporation causes sedimentation; and the biological by the fact that plants of so low an order of development that they consist of hardly anything more than a mass of gelatine, growing in the water, form in their bodies siliceous spicules and become incrusted with silica.

This variety of causes results in a variety of forms, and the deposits resemble at times cauliflower, cabbage, mosses, leaves, sponges, corals, stalactites, spicules and spheres. Sometimes the material piles up in regular forms as the Bee Hive geyser, or in bizarre forms like the Grotto, or in great masses like the White Pyramid, or in rounded craters like Old Faithful, or in flat forms without elevation like the Excelsior.

Not less interesting than the forms of the deposits, and far more beautiful are the colors which are in large part due to the algæ. We are not surprised that grass is green, or that when the chill of winter strikes the leaves of the forest they turn to yellows and reds and golden hues. No more wonderful is it, though perchance more surprising, that plants which live in boiling water or warm water or cold water should have many colors.

The Mammoth Hot Springs show against dazzling white deposits, patches of delicate pink or salmon hues which deepen along the edge of the basins, where moistened into yellow, brown and red. The pools of the geyser region show red, rose, cream, brown, emerald, green and blue hues.

The paint pots are reddish brown, umber, pink, blue and grey.

The largest and most impressive mass however is seen in the Grand Canon. Here it is chiefly caused by mineral matter.

The great mass of rhyolite through which the waters of the Yellowstone have carved their way had been thoroughly decomposed by hot waters and gases. Thousands of steaming vents, solfataras, and fumaroles can be seen by one who has the daring to descend into the canon. Boiling water, scalding vapors and fiery gases had worked through and through, corroding, eating, destroying, decomposing and transforming the great mass. It was a rough experience. Then the weakened rock was attacked by the river and carved, worn and scoured.

The rapidity with which it was worn away was due to the weak condition of the rock as well as to the great volume of rapidly running water and the rapidity has resulted in steep sides, sharp pinnacles and freshness of coloring. The spires and minarets have not had time to be leveled and the steepness of sides prevents their being overrun with vegetation or covered with faded materials.

The result is the scene which charms the beholder.

The grand canon of the Arkansas is impressive. The solemn grandeur of the Yosemite overwhelms and fills the mind with thoughts of vastness and sublimity. But the beauty of the Yellowstone charms and delights and thrills. As by

the brink of the falls one first views the steep slopes separated at the bottom far below by a silver thread of rushing water with its sides studded with minarets and spires and pinnacles and adorned with patches of red and yellow and purple he beholds Nature in her holiday attire, disclosing a union of sublimity and beauty that is without parallel.

The youth of the country, the hardships which it has suffered, the society which it keeps—these things, represented by elevation, volcanic eruption, ice and water erosion, contact of heat and vapor, of acid and water—these things have united to produce the "Wonderland of America."

Note.—Relatively few people visit the park. More would probably go if they knew that the expense can be adapted to one's pocket-book. People wishing luxury will find the park hotels first-class and transportation comfortable at about ten dollars per day. Those wishing to be more economical can use the pleasant permanent camps and transportation furnished by W. W. Wylie, Bozeman, Montana, for five dollars per day.

Or one can organize a camping party himself and travel more cheaply, although teams in that region are expensive. At least one week is needed for "the tour."

DUAL CHARACTER OF THE KINDERHOOK FAUNA.

By CHARLES R. KEYES, Jefferson City, Mo.

In the Mississippi valley the Kinderhook formation is commonly considered as forming the basal part of the Carboniferous system. It is well developed at Burlington and other parts of southeastern Iowa. Farther southward along the Mississippi river it is also well exposed. In common with the several members of the Lower Carboniferous or "Subcarboniferous" it stretches around the Ozark uplift to the westward and southwestward, probably reaching as far as northwestern Arkansas.

No single formation of the region has received more attention than the Kinderhook. Ever since the formations of the

Mississippi valley first began to receive attention its fossils have attracted as much notice as those from any of the associated strata. Notwithstanding this fact the geological age of the beds composing the Kinderhook was the subject of considerable discussion until finally Meek and Worthen* set forth their evidence in support of its being Carboniferous in age. Their conclusions have been generally adopted. The subject, however, has been considered anew in the recent reports† of the Iowa and Missouri geological surveys. The main facts so far as they bear upon the theme in hand, are essentially as follows: Although for many years past the Kinderhook beds have been regarded as the base of the Lower Carboniferous, or Mississippian series, a decided Devonian facies of the contained fossils has always been observed. This peculiar aspect has occasioned much comment. So much were some of the earlier geologists impressed with this character of the organic remains, that they hesitated but little in referring the beds in question to the upper Devonian.

Owen,‡ who was the first to give attention to the geological details of the rocks as exposed along the Mississippi above the mouth of the Missouri river, limited the term "Subcarboniferous," which hitherto had long been applied to all the strata below the Coal Measures as far down as the Hudson River shales, to those strata which are known as the basal stage of the Mississippian series. The Louisiana, or Lithographic limestone was not, however, included, for his "argillaceous marlites" was manifestly his lowest member of the series. Swallow,§ Hall‖ and White,¶ who were well acquainted with the rock section and its fossils, correlated the beds immediately below the Burlington limestone with the Chemung (Devonian). In northeastern Missouri and adjoining portions of Iowa and Illinois, the "Chemung" includes the Chouteau limestone, the Vermicular shales and the Lithographic limestone. Hall, who had studied more particularly in Iowa, erro-

*Amer. Jour. Sci. (2), vol. XXXII, p. 167, 1861.

†Iowa Geol. Sur., vol. I, pp. 51-53, 1893; and Missouri Geol. Sur., vol. IV, pp. 52-55, 1894.

‡U. S. Geol. Sur. Wisconsin, Iowa and Minnesota, p. 92, 1852.

§Geol. Surv. Missouri, Ann. Rep., p. 101, 1855.

‖Geol. Iowa, vol. I, p. PP, 1858.

¶Proc. Boston Soc. Nat. Hist., vol. VIII, p. 289, 1862.

neously regarded the sandy shales or yellow sandstones below the great limestone at Burlington as identical in age with lithologically similar strata 50 miles to the northward, at the mouth of Pine creek in Muscatine county. The Pine creek rocks have recently been shown by Calvin* to be, beyond all doubt, not only not equivalent to the Burlington beds, but not Carboniferous at all. As shown by abundant fossils they belong to the Hamilton division of the Devonian as known in Iowa. Hall, having investigated this northern locality more thoroughly, perhaps, and being impressed with a manifestly typical Devonian fauna, very naturally came to the conclusion that the formations of the two localities being the same, were both older than the Carboniferous, whereas they were widely separated in point of time. But Meek and Worthen,† who had considered chiefly the fossils in the upper part of the so-called "Chemung," both at Burlington, Iowa, and at Kinderhook, Illinois, a few miles from Hannibal, Missouri, regarded the fauna contained to be Carboniferous rather than Devonian, and the whole sequence was accordingly placed in the former.

Reference to the published vertical sections of the Kinderhook shows that the formation as commonly known in the region is a triple division, the upper and lower parts or subdivisions being limestones, and the middle one shale. At Burlington no fossils heretofore noted have been found except in the upper portion of the formation. It has been only very recently that an extensive and interesting fauna has been discovered in the clayey portion much lower down. Here the lower calcareous member, if it exists, is not exposed. At Louisiana and in the vicinity, the median member has always been considered unfossiliferous, as has been also the lower limestone except at the very base. Marion and Pike counties, Missouri, at Hannibal, Louisiana and Clarkesville principally, were the leading localities for many of the "Kinderhook" fossils originally described by Shumard, Hall, White and Winchell. Most of these forms have a most decided Devonian aspect. In consequence a peculiar and characteristic physiognomy is imparted to the faunas of the three members

*AMER. GEOL., vol. II, p. 25, 1889.

†Amer. Jour. Sci., (2), vol. XXXII, p. 167, 1866.

taken as a whole. Heretofore little or no mention has been made concerning the exact horizons of the fossils in question, mere reference to the "Lithographic" limestone or "Kinderhook beds" being considered sufficient. Lately, however, extensive collections of fossils have been made at all three places mentioned, as well as at many neighboring localities. Everywhere the Lithographic, or Louisiana, limestone has been found to be essentially devoid of organic remains, except an occasional form in the thin sandy partings above the bottom layer, which is less than one foot in thickness. At the very base of the limestone is a thin seam of buff, sandy shale, seldom over three or four inches in thickness. This seam is highly fossiliferous. It contains the *Productella pyxidata* (Hall), *Cyrtina acutirostris* (Shumard), *Chonetes ornata* (Shumard), *Spirifer hannibalensis* (Shumard), and a host of other forms, many indistinguishable from species occurring in undoubted beds of the Western Hamilton.

When this phase of the problem arose, as elsewhere presented, it appeared that, lithologically, the thin, sandy layer was more closely related to the underlying shales than to the overlying limestone; that faunally, it had very much clearer affinities with the Western Hamilton (Devonian) than with the "Kinderhook" (Lower Carboniferous). In Iowa the "Devonian aspect" of the Kinderhook faunas disappeared, largely, upon Calvin's recent discovery that the "Chemung" sandstones of Pine creek, in Muscatine county, Iowa, were in reality true Devonian. In Missouri the same Devonian facies of the fauna contained in the lowest member of the recognized Carboniferous was removed almost completely, by casting out the species found in the thin sandy seam at the base of the Lithographic limestone. The faunas of the Devonian and Carboniferous of the upper Mississippi valley thus became more sharply contrasted than ever. The apparent mingling of faunas from the two geographical sections manifestly had been based upon erroneous assumptions rather than upon the detailed field evidence. It was stated* at the time that after eliminating from "the Lithographic limestone, the extensive fauna commonly ascribed to it, and which came only from a thin seam lying below the calcareous member, its real geolog-

*Iowa Geol. Sur., vol. I, p. 53, 1893.

ical age became a problem yet to be solved. The few fossils known from the limestone itself have been rarely met with. It is not at all unlikely that the lower limestone of the Kinderhook may prove eventually to be of Devonian age. But until abundant evidence to this effect is found, it seems advisable to still consider the Louisiana (Lithographic) limestone as the basal member of the Carboniferous."

The fact that the correlations of the Kinderhook have been so widely variant and as later work has clearly shown, in large part erroneous, must be ascribed mainly to insufficient exact data, since nowhere, as it now appears, have investigations been detailed enough, in the attempts to solve the problem, to enable the critical evidence to be formulated. The beds of the uncertain zone have been placed first in one system and then in the other, sometimes with a loss of some of its layers in the process of the shifting, and sometimes with a gain of others. These strata of undeterminate age may be regarded as including all those lying between the base of the Burlington limestone and the strata which are commonly put down as the western representatives of the New York Hamilton. Although these beds were originally placed in the Carboniferous, then assigned altogether to the Devonian, and again transferred to the Carboniferous, where they have by common consent and in the absence of further direct inquiry long remained, the accumulating evidence now points to their proper place in part back in the older of the two systems and in part in the younger. However, grounds for this return in large part to the earliest definitely expressed view are very different from those which were adopted in the beginning. Singularly enough while the reasons for their early reference to the Devonian were found of late years to be entirely erroneous, the first conclusions were practically correct, in fact, for the particular district under consideration along the Mississippi river; the premises were totally wrong, and the decisions were founded upon faulty correlations. Herein lies the confusion which has so long existed regarding the proper position of the beds.

Very recently the whole subject has been taken up again, and as a result it has been necessary to considerably modify the views previously expressed. A careful examination of

the Lithographic beds has been made with the special object of discovering fossils in the seemingly unfossiliferous layers above the base, and of determining the vertical distribution of the organic remains. The locality selected was Louisiana, in Pike county, Missouri, where the exposures were unusually favorable, where the vertical section was complete from the Trenton to the upper Burlington, and where there was an abundance of fossils. The vertical section and the exposures are so extensive for a single locality that the facilities for determining the exact range of the various faunal zones stand unrivalled in the whole region. Moreover, a key to the stratigraphy of the entire province is furnished. Owing to usually favorable opportunities afforded by the extensive fossil collections of Mr. R. R. Rowley and the supplementary special field work the results are very complete. The determination of the faunal zone and their most important relationships as bearing upon the stratigraphy of the region are therefore of great interest.

In considering the faunal features of the succession the chief interest centers in the nature of the fauna of the Kinderhook as a whole, and of each of its several parts. The three most prominent considerations are: (1) The general facies of the fauna in its entirety, and the elements giving it its predominant features, (2) the character and genetic relations to the basal fauna, and (3) the upper limit, if any can be made out, of the fauna most characteristic of the formation.

First. Heretofore the attempt has been made always to treat the organic remains contained in the "Kinderhook," "Chouteau," or the "Chemung" as constituting a single fauna. Owing to the heterogeneous beds that have been placed together it has been the chief mission of later work to take out from time to time the various incongruous parts which were originally correlated with this formation. Thus gradually at its typical localities the terrane has finally come to be more clearly understood.

The fauna contained in the "Kinderhook" when deprived of the elements which are in reality wholly foreign, presents a very different facies from that generally ascribed to it. With the light of definite zonal distribution of the fossils there ap-

pears to be, instead of a single compact and characteristic group of forms, two very distinct faunas. This is nowhere more clearly shown than in the locality which may be regarded as typical and in which the faunal zones have been determined with considerable accuracy and corroborated by evidence from other districts. Owing to the indefinite knowledge which has long existed regarding the exact horizons at which the various genera and species occur, the general faunal facies of the "Kinderhook" has heretofore borne a composite and not a pure physiognomy.

A tabular arrangement of all the species of fossils that are recognized at a typical locality of the Kinderhook, and that range from the Silurian to the upper Burlington, has brought out very clearly some important facts which have been overlooked. The first of these is the close affinity of the faunas from the lower two members of the "Kinderhook," with the underlying Devonian, and the second is the sharpness with which the lower fauna stops at the base of the Chouteau, and the abruptness with which an entirely new fauna begins at the same level.

Second. The components of the lower fauna comprise those forms which occur in the Louisiana limestone and the Hannibal shales. As a whole the fauna is evidently closely related to that occurring in the western Hamilton. Some of the species, though bearing different names, are in reality identical with typical forms of that formation. As already stated, the fossils have been found, with few exceptions perhaps, only at the basal portion of what is called the Louisiana limestone, in a thin sandy layer which is lithologically similar to the partings in the limestone itself. The results of the latest investigations show that many of the forms actually extend upwards, some of them being practically unchanged through the whole Louisiana to the top of the Hannibal. Thus far not a single species of this fauna appears to occur higher, or in the overlying Chouteau. Many of the forms also range downwards into the dark colored shale below, which is regarded as of Devonian age.

The general impression derived from a tabular arrangement of all the species is that the lower zones, forming the Louisiana, the commonly accepted base of the Carboniferous, are

faunally very closely related and that those constituting the overlying Hannibal shales also have close affinities with the lower member. No special effort was made to determine the full faunas of the higher beds, as the critical evidence that was needed was in regard to the fauna of the Louisiana (Lithographic) limestone. The shales have, however, proved to be very barren in organic remains. Towards the top where they become sandy a number of the lower species are found. That the shales do not appear to be fossiliferous is not remarkable. Since they manifestly do not contain abundant remains in a good state of preservation they have not been searched so carefully by fossil collectors as have the other beds. At Burlington, where there are excellent exposures and numerous active collectors, besides a host of transient ones, the same shales remained for half a century without a fauna to be ascribed to them. But of late they have been shown to be abundantly supplied with fossils. Without exception the latter appear to be characteristic Devonian forms. As yet, however, the fauna has not been studied sufficiently to be specifically listed, but the brachiopods are for the most part very similar to, if not identical with, the species found in undoubted Devonian shales farther northward. The cephalopods are represented by large forms of *Cyrtoceras*, *Gomphoceras* and *Phragmoceras*. One belonging to the latter genus may prove to be Winchell's *P. expansum*. Another very characteristic phase of the fauna is the non-trilobitic crustaceans, of which a very considerable number have been found. They have very close affinities with *Tropidocaris* and *Amphipeltis*.

It appears, then, that the Devonian fauna characteristic of the region extends up to the top of the Hannibal shales in northeastern Missouri, at Louisiana especially, and that the "Kinderhook" shales of southeastern Iowa, as typically developed at Burlington and corresponding in great part to the Hannibal shales, appear to carry no other remains than those of pronounced Devonian types. The upper part of the section, usually regarded as Kinderhook at Burlington, in fact all the thin limestone and sandstone bands down to the main body of shale may be now more properly considered as the equivalent of the Chouteau limestone, that is, the uppermost member of the so-called Kinderhook in Missouri.

Third. One reason that the fauna of the Chouteau (original) limestone has not been better understood in its relations to the faunas occurring lower in the so-called Kinderhook, and higher in the Burlington limestone, has been that in the localities where the lower Carboniferous has been most thoroughly and widely studied, that is along the Mississippi river, the Chouteau, as commonly recognized nowhere crops out along the great stream, except perhaps in the vicinity of the town of Louisiana, where, under the typical Burlington, there is an earthy limestone six to twelve feet thick, which has been considered a part of the latter, but which is not believed to be the attenuated edge of the Chouteau or its equivalent. At any rate in the immediate vicinity the undoubted Chouteau attains a thickness of fifteen to thirty feet.

Over two hundred species of organic remains have been identified at Louisiana in the so-called Kinderhook and the Burlington beds. By arranging these according to the faunal zones recognized several important facts are brought out. It is found that at the base of the Chouteau limestone there is a line on either side of which there is, with one possible exception, not a single species that is found on the other. Forty-three species occur in the "Kinderhook" below; 157 in the strata above. The one doubtful case is a possible variety of *Spirifer hannibalensis*, a widely distributed type. Thus the upper fauna nowhere extends beneath the base of the Chouteau; and the lower fauna nowhere rises above the same level. The species belonging to the fauna beginning in the Chouteau extend upward into the Burlington. While in the latter many new forms appear they do not immediately replace the typical Chouteau types. The strangest feature of all is that the many new species which appear in the second bed of the Burlington, some ten feet above the base of that formation, are largely so-called Kinderhook forms, not altogether from the Chouteau of the immediate neighborhood but from the limestones which occur just beneath the Burlington limestone in other localities, as in the city of Burlington.

The following general conclusions are deduced:

1. The most marked change in the succession of faunas in the entire sequence of rocks commonly known as the lower Carboniferous or "Subcarboniferous" as represented along

the Mississippi river, is at the base of the Chouteau limestone (limited). At this horizon there is so great a faunal hiatus that there is scarcely a species that is common to the beds on either side.

2. That instead of the so-called Kinderhook containing in its fauna a mingling of Devonian and Carboniferous types there are really two faunas that are perfectly distinct, well defined, and do not merge into each other. The one is characteristically Devonian in character, and the other is strikingly Carboniferous in general aspect.

3. The basal line of the lower Carboniferous or Mississippian series is the base of the Chouteau limestone, and the lowest member of the four-fold series contains only one formation, instead of the three heretofore commonly ascribed to it.

4. The early reference of a part of the so-called Kinderhook or "Chemung to the Devonian was correct in fact, though done entirely through erroneous correlations and a misconception of the real facts.

5. The evidence afforded by the faunas of the region is in close accord with the facts obtained regarding discordant sedimentation and the stratigraphical and lithological characters of the formations themselves.

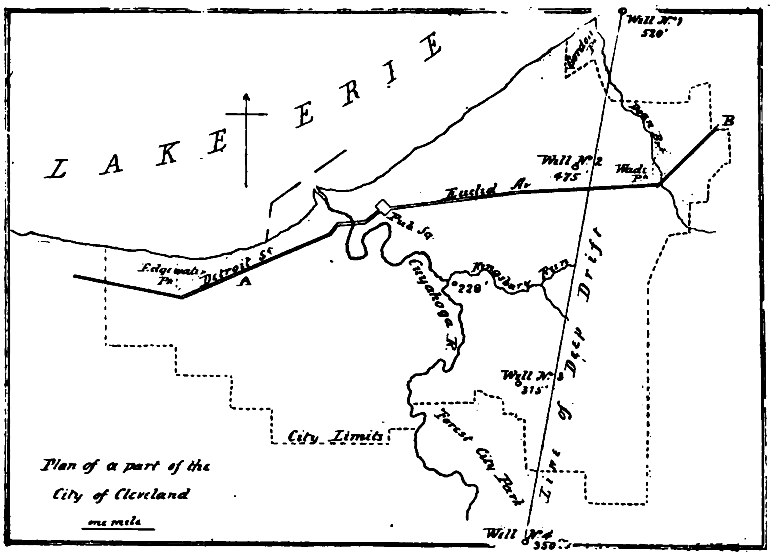
THE PREGLACIAL CUYAHOGA VALLEY.

By S. J. PIERCE, Cleveland, O.

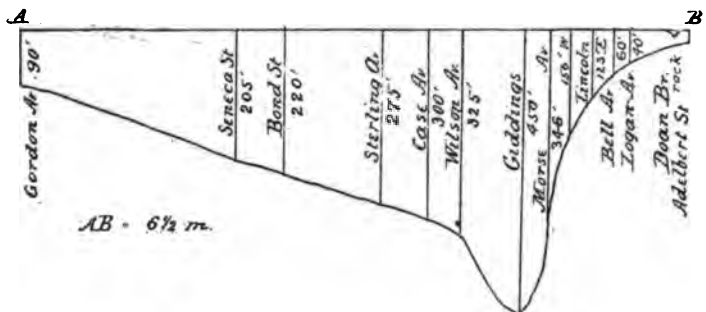
(Plate XIII.)

The Cuyahoga river is a stream emptying into lake Erie within the city limits of Cleveland, O. The account given in vol. I of the report of the Ohio Geological Survey, by Dr. J. S. Newberry, showing the existence of a much greater depth to the Cuyahoga valley, has been quoted by many later writers as evidence of the fact that the rocky bottom of lake Erie is situated much below the bottom of the clay covering it, and which is reached at an average depth of about 83 feet below the lake level.

In his report showing that the former bed of the Cuyahoga river is situated far below the present one, Dr. Newberry gives

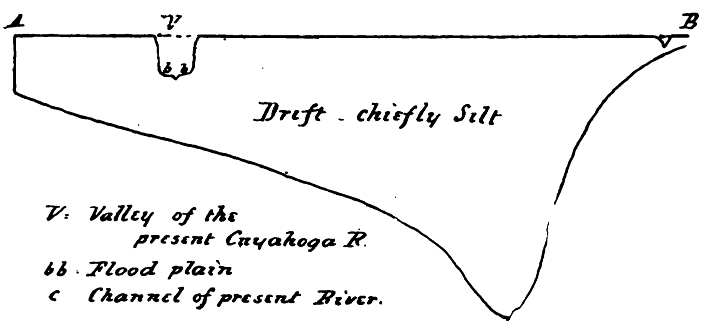


SECTION I.



Sections across the Cuyahoga Valley on line AB

SECTION II.



most prominence to a well drilled by the Standard Oil Co. at the mouth of Kingsbury's run, (a small stream emptying into the Cuyahoga river about two miles from its mouth) which reached rock at a depth of 238 feet. As the mouth of this well is about ten feet above the level of lake Erie, this would give the bottom a depth of 228 feet below this level, and also show the existence of a preglacial valley much deeper than that of the present Cuyahoga. Since that time many borings have been made in all parts of the city and adjoining townships, which throw much new and interesting light on this preglacial valley and its location. If the results of these more recent borings have appeared in any writings on the geology of the region, I am not aware of the fact. The latest work on this subject, to my knowledge, is by Prof. Warren Upham, on "The Preglacial and Postglacial valleys of the Cuyahoga and Rocky rivers," in which he gives the maximum recorded depth of the preglacial Cuyahoga at 228 feet below the level of the lake. Also Dr. J. W. Spencer in his work "History of the Great Lakes," written in 1894, gives the same figures, 228 feet, as showing the greatest known depth of lake Erie.

The object of the present paper is to compile the records of more recent borings and present the results as shown by them. In this, much assistance has been freely given by Mr. F. S. Gilbert, contractor and driller of this city, who has a record of many of the deepest wells.*

The result of these subsequent borings has been to bring to light three prominent facts: First, that the ancient gorge is very much deeper than formerly supposed; second, that the greatest depth yet shown by the drill is near Gordon park, about five and one-half miles to the east of the present mouth of the river; third, that the line of deep drift which fills the preglacial valley extends approximately northeast to southwest from near the east side of Gordon park, past Forest City park, as located on the accompanying map.

*Mr. Gilbert has kindly furnished the following additional confirmation of the details here given:

At the request of Mr. S. J. Pierce, I write to verify the records of several wells which I gave him. I have read a copy of his paper and also examined the profile view of this valley. In regard to both I would say that the records are correct. These borings have been made by me, and cover a period of seventeen years. F. S. GILBERT.

CLEVELAND, O., June 9, 1897.

Deep Wells.

About thirteen years ago a well was drilled a little east of Gordon park, to a depth of about 520 feet. (Well No. 1 on map.) Absence of rock at that depth, and inability to make headway in the quicksand and gravel, caused the well to be abandoned. As this seemed a phenomenal depth, as compared with previous wells, without striking rock, it was doubted by some at that time whether such could be the case. But subsequent borings have confirmed this record in many different places, within and without the city limits, though none have quite reached the depth assigned to this one. Another well, No. 2, drilled within the last few years near the intersection of Madison and Hough avenues reached rock at the depth of 475 feet. This is, I think, the deepest well to show rock in the line of deep drift, although it may not reach the deepest point in the preglacial valley. Two other wells have been drilled along this northeast and southwest line in neither of which was rock reached. One is at the west end of Mound street, No. 3, east of Forest City park and was abandoned at a depth of 315 feet, no rock being reached. The other, No. 4, was on the property of the Newburg Fertilizer Co., situated on the Cuyahoga flats, outside the city limits. The well drilled here was abandoned in the drift at a depth of 350 feet. The record of this well is significant, owing to its distance from the lake, being about eight miles from Gordon park, and its situation being seventeen feet above lake level. This well would then give a clear record of drift below lake level of at least 333 feet. In regard to the level of the two wells previously mentioned: well No. 1, east of Gordon park is situated not over fifty feet above lake level; its depth being 520 feet would leave 470 feet as known depth to which drift extends below lake level. The other well, No. 3, at west end of Mound street, while not so deep, still serves to show the course of the valley. The levelling for this is 112 feet, giving a depth of 203 feet below lake level. The levelling for the well 475 feet deep at Madison and Hough Ave. is 83 feet. This gives 392 feet below lake level at this point. While these are not all the deep wells, they are among the deepest and serve to give us a clue to the old channel, and as shown on the map, it is seen to be far to the east of the present river mouth. To show the relative proportions of the

gorge, a cross section, section No. I, has been prepared from records of borings. This cross section is along a line approximately parallel to Euclid Ave. and Detroit St. The streets which cross this line are given, and also depths of wells nearest to them. This line then represents a line of borings, from the depth of which, the profile of the gorge or preglacial valley is determined. This line is not marked on the accompanying map: but a line drawn from A to B will show it. It will be seen from this profile, that the deepest part of the channel lies between Madison and Wilson avenues. From this point passing west, a gradual rise of the rocky floor takes place, until the shale appears again as surface rock. In this cross section no account of the 475 foot well is taken.

Section No. II shows the relative position and depth of the modern river to the preglacial gorge. This valley marked V on section is from one-half to one mile,in width with an average depth of about 100 feet, within the city limits. The bottom of this is composed of alluvial deposit. Along this valley "meanders the modern river, whose only right to the title of river seems to be in the magnitude of the deserted channel of which it is the sole occupant."

The location of the well at the mouth of Kingsbury's run, as given by Dr. Newberry, will thus be seen to be on that part of the valley which rises to the west. It gave to Dr. Newberry the clue to a deeper valley, but did not locate its direction or give its greatest depth. As thus shown, the preglacial Cuyahoga valley below lake level is deeper than the gorge of Niagara. And however vast we may think the time required to excavate the gorge of Niagara from Queenstown hights to the present falls, yet this drift-filled valley of the Cuyahoga on which the city of Cleveland now stands was eroded to its deepest point, filled with drift and partially re-excavated again by the modern river, before Niagara had an existence.

But whether the depth reached by the drill in this city shows the deepest point of drift or not, (and this can only be determined by borings which may be made in the future) enough is known at present to warrant us in definitely assigning a greater depth to lake Erie, and to show that it was not the shallow basin we now have, but was comparable in depth with the sister lakes.

The Drift.

This valley as described and shown in profile, is filled with drift to an average hight of about 100 feet above the lake. The upper thirty or fifty feet of this consists of sand and gravel distinctly stratified, as may be seen in the excavations made for buildings. It is the "delta sand" of Dr. Newberry. This sand and gravel was laid in its present position by the waves when the lake stood at a higher level than now, and shows such wave action most distinctly. The clay lying beneath this and constituting the drift, not only fills the valley, but forms the covering for the deep rocky bottom of the lake. This is called by Dr. Newberry the Erie blue clay, and is "supposed to be the fresh water and interior equivalent of the Champlain clays, which were deposited in the earlier portion of the drift period on the Atlantic coast when it was sunk 500 feet or more beneath the ocean." It is easily recognized by its bluish or dark cast and is mixed throughout with layers of quicksand and gravel and some striated pebbles, mostly of Canadian origin. It is devoid of fossils, but in some places the delta sand is separated from the clay by a layer of carbonaceous matter. Mr. F. S. Gilbert, in drilling a well near the public square, passed through a log about two feet in diameter at a depth of 125 feet from the top of the well, this being far below the band of carbonaceous matter.

The clay as exposed is distinctly laminated and shows unmistakably the action of water. It was laid down on the bottom of the lake when lake Erie as such did not exist, but was a part of a much larger sheet of water, covering probably not less than 200,000 square miles.

Origin of the Valley.

It is believed by many that the continent prior to the Ice age stood from 3000 to 5000 feet above its present level. From among many examples which show such former uplift, may be mentioned the case of the Hudson river valley. The continuation of this submarine channel has been traced by detailed surveys to the edge of the continental slope, a distance of about 105 miles southeast of Sandy Hook, and 120 miles from New York. Its outermost 25 miles are a submarine fjord 3 miles wide and from 900 to 2250 feet in vertical depth meas-

ured from the crests of its banks. The Hudson as thus formed is a valley of erosion.

It was during this high continental altitude that the Cuyahoga cut its deep channel. This was probably during the later Tertiary or early Quaternary period. As the Hudson, St. Lawrence, and other rivers emptying into the Atlantic and Pacific oceans through deep submarine fjords are monuments of the high altitude of the continent, so the Cuyahoga is a witness of the fact that the preglacial rivers emptying into the lake basin, had much deeper channels than heretofore assigned to them. What light the present deep channel of the Cuyahoga river may throw on the depth of the lakes and their former drainage remains to be worked out. But enough has been given to show that the bottom of lake Erie must be sought for much below what has hitherto been assigned as its maximum depth.

NOTE. Since the above paper was written another well has been begun in Cleveland which so far as it has yet been drilled gives further data in support of the conclusion reached in the above paper. It is already about 350 feet deep and is situated at the crossing of the Cleveland and Pittsburgh railway and Central avenue. The work is at present at a standstill owing to the breakage of the cable when the bit was passing through a bed of very tough boulder (?) clay through which it has proven impossible to drive the casing though the drill was 15 or 18 feet below the bottom of the pipe.

EDITORIAL COMMENT.

THE MISSOURI GEOLOGICAL SURVEY.

The State of Missouri has had a checkered experience in its efforts to make a geological survey of its domains. It has been liberal, if not lavish, in the appropriation of money, and it has, to show for it, a disjointed and incomplete set of reports and maps, beginning with that of Swallow, in 1853, and ending with that of Keyes in 1897. In this interval the following geologists have been in charge of the survey, for periods of short duration, separated by intervals of inactivity: Swal-

low, Hagar, Norwood, Pumpelly, Broadhead, Williams (C. P.) Winslow, Keyes. It is plain that, with much that is incomplete and lost on the change from one administration to another, much is also done in duplicate. Indeed in several instances the same areas have been twice examined and reported, and in some cases twice mapped. It is not apparent that, up to the present, politics has had anything to do with this broken and discouraging history; but the present board of control, which is a creature of the governor of the state, has fallen under the bane of partisan political intrigue and has given the Missouri survey the worst adverse blow it has yet suffered.

In all the country no state survey has surpassed the Missouri survey in energy, and in important and valuable results while under the management of Dr. Keyes. Since 1894, at which date the survey devolved on him, more has been printed and desseminated concerning the geology of Missouri than in all the previous years of its history, No citizen of the state nor any geologist outside of the state, could find any fault with it. It worked smoothly, continuously and fruitfully. But it has been brought to a sudden close. In name the organization continues, and the usual salaries will be paid from the State's treasury. As an organ for the development of the geology of the state, it has met the withering hand of politics with fatal results. At a recent meeting of the board of managers, the state geologist was removed and there was elected in his place a man whose name was never pronounced as that of a geologist, and whose only qualification for the position consists, as reported in the state press, in having efficiently intrigued with the governor in re-forming the board of managers, and in having served once as a guard at the penitentiary. These qualifications stand very low in the geological scale. The records and cabinet which have been accumulating for the past eight years under the present law, were immediately consigned to the attic of an old building, all field-work was ordered abandoned at once, and several important pieces of work which were almost ready for publication were "not needed." The only reason urged for such unprecedented change of policy was that the geologist heretofore in charge of the work "was not active enough in practical politics." Prof. E. M. Shepard, of Drury College, Springfield, the only

scientific member on the board, resigned on the spot, and as yet the governor has not been able to induce any self-respecting scientific man in the state to accept the appointment to the vacancy. Gov. Stevens, who is president of the board ex-officio, appointed as his associates a driver of a sprinkling cart, a "ward heeler" from one of the large cities, a member of a "loan" office, and Prof. Shepard who belonged to the previous board, and who resigned as soon as the dastardly action of the other members was carried out. This explains the inappreciation which was manifested of scientific, educational and practical geology. It is so ridiculous and at the same time so nearly a criminal act, that it is difficult to comprehend how any governor of a great State could be led into it. He jeopardizes the material interests of a great and enlightened commonwealth, for the personal greed that lurks in political intrigue and ambition. Of all the instances of robbery of this kind of which the country has any knowledge, this is one of the most flagrant and inexcusable. The transaction which removes Dr. Keyes from his position is of small consequence to him, and his interests are not here considered. That which we lament, and which we protest against vigorously, and with all the vehemence of which we are capable, is the wanton prostitution of the good of the people, as centered in the geological survey of the state, to the petty, personal politics of the hour. We have called it robbery. It is worse than open robbery, because that is crime, and is punishable, but this act goes forth as justifiable, and is unpunishable. It is a base betrayal, as well as robbery. It is treachery, robbery, deception, malfeasance and wilful plunder, cloaked under the pretended administration of law.

There is a defect in many of the state laws that establish such surveys. The extreme of this defect is exemplified in Indiana, where the state geologist is nominated by the politicians and is elected yearly by the successful party. More moderately this defect is felt in such instances as in Illinois and Kentucky, where the geologist is subject to appointment and removal after each change in the political phase of the State at the will of the new governor, and its slowest results are seen in such cases as in Missouri where the governor has the power to re-form, after each election, the board of control,

thus making the geological survey in all cases a contingent of politics. This action in Missouri is a lesson for the future, and stands as a warning finger-board to those who may have to frame laws establishing such surveys, pointing to the danger that lies in the controlling power of politicians. The remedies for such dangers lie in making the law provide for the following as nearly as they can be enacted.

1. The governing board should not all go out of office at once.

2. The governing board should be men of education and of scientific attainments, and if possible should represent several established scientific institutions existing in the state.

3. The survey headquarters should be at some state institution, preferably at the state University, and last of all in the state capitol.

4. The state geologist should be required to abstain from "practical politics", and should serve until the survey is done or be removable only for good cause.

Science, the supreme court, and the church are the three things that ought to be entirely free from the shifting conditions of politics. A state geologist, charged with the scientific interests of the State, as expressed in the law which he has to execute, has in his hands the material as well as the educational welfare and reputation of the State. His duties are not fleeting and transitory, but far reaching and permanent in their results, and if he be a true scientist who realizes the responsibilities of his position he will know little and care less about the politics of the State. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geological Survey of Mexico, Bulletins 4, 5 and 6, 1897. This report begins with a memoir of Dr. Antonio del Castillo, the late director of the Mexican survey, by Sr. José G. Aguilera, prefaced to which is a likeness easily recognized by all who met the original at Washington in 1891, at the fifth International Congress. Following this comes the "prologue" or administrative report by the same writer, then a brief account of the work of the season in the province of Durango by Sr. R. F. Buelna, in the regions of the Sierra Madre, west of Mexico in Tepic, Jalisco and

Colima, by Sr. Ezequiel Ordoñez, and in the states of Pueblo and Tlaxcala, by Sr. José G. Aguilera. Then come about twenty pages of altitudes in various parts of Mexico, mostly of moderate amount, up to 2000 feet, on the plateaus, and not containing any of the mountain peaks. This concludes the first part of the volume.

The second part, which will be of more interest to geologists generally, commences with a summary of the geology of Mexico, by Sr. José G. Aguilera. Beginning with a short geographical account of the country, he proceeds to a more minute geological description.

"Geologically considered, Mexico is composed of three parts. The first, the more ancient and least extensive, consists of a great mass of granite, gneiss and schist, which occupies most of the south of the country, and reaches from the Pacific to the eastern coast."

"The second containing deposits dating from Palæozoic time to our own day is found in the northern, southern, eastern and central parts of the country; and the third, almost of equal size and importance, is principally composed of eruptive rocks of modern date."

"The archæan rocks of Mexico are numerous, varied and consist among others, of a porphyritic gneiss like an 'augengneiss'--gneissic phyllades, passing into the former and mica-slates conformable to the foregoing."

The existence of Silurian strata is evidently doubted. Sr. Aguilera says: "There are in our collection a few specimens of slate containing good individuals of *Orthis testudinaria* Dalman, a Trenton species. This was sent to Dr. Ant. del Castillo and bears the label 'Estado de Guerrero.' But the late director went several times to the locality to verify the statement, and could find no trace of any fossil in any rocks likely to have yielded it."

The Devonian system is apparently in the same state. A Devonian goniatite, said to come from Apulco, has in like manner called out several journeys to the place, but all to no purpose.

The existence of Carboniferous strata is, however, proved by the occurrence of *Productus semireticulatus*. But certain beds which had been referred to the Upper Carboniferous by Frazer, Heilprin and Hall have now, on more and better evidence, been placed in the Cretaceous system, as they hold *Lima*, *Anomia*, *Scaphites*, etc.

The Carboniferous of Mexico has thus far proven very barren ; a meagre list of four species is preserved and only two of them specifically identifiable, composing its whole known fauna.

The different formations composing the Mesozoic system are not all represented in Mexico, those which are found being the upper part of the Triassic and Jurassic and almost all of the Cretaceous. The rocks of the Triassic are quartzose sandstones and hard shales varying in composition both vertically and horizontally. In consequence of strong and long continued erosion the rocks of this system have very largely disappeared, and a number of small patches are all that remains to testify to their extent when formed. The fossils are plants and were studied by the late Prof. Newberry, whose names, with few additions,

comprise the whole list. The Jurassic is less known and has been confused in part with the overlying Cretaceous with which it is perfectly conformable. It holds a large fauna of well known genera but of chiefly peculiar species. "Among those from the Upper Jurassic are some such as *Aegoceras* and *Stephanoceras* belonging strictly to a rather lower horizon."

The Cretaceous deposits cover a wider area and are divided into Lower, Middle and Upper. Their composition resembles that of the preceding in being for the most part mechanical, and showing a great absence of lime. They are cut in many places by eruptive rocks of later date, Tertiary and even Quaternary, consisting of diorites, quartz-andesites, hornblende-syenites, granulites, diabases. The fauna is fairly rich and comprises numerous families, Rhizopoda, Anthozoa, Echinoidea, Vermes, Lamellibranchiata, Gasteropoda, Cephalopoda, Pisces, with one doubtful reptile. The absence of Brachiopoda is a remarkable fact and no allusion is made to it in the text. Possibly it is an accidental omission. Of the Tertiary only the Eocene and the Lower Miocene are present in any fullness, the middle and upper portions being very local. The former lies chiefly along the gulf of Mexico and the latter along the gulf of California. A list of fossils shows, as the author remarks, that it is not possible in all cases to draw a line between the Tertiary and Quaternary groups.

The last named occupies a very large area in the upper valleys and central tableland. The materials are, as usual, loose and fragmentary, but some of them plainly indicate deposition from heated waters.

Mexico, says our author, was in the earliest time a group of islands which were subjected to severe erosion in Azoic days. Elevation prevented the deposition of Silurian and Devonian strata, and Mexico then "presented a large continental surface or collossal peninsula of North America stretching from northwest to southeast. The absolute lack of the first division of the Carboniferous authorized the belief that during the time when equivalent strata were deposited elsewhere the elevating movement continued and the geographic outline remained on the whole unchanged or with slight addition." The Triassic seems to have been a time of lakes and lagoons and of gradual subsidence and was followed by the Jurassic, "characterized by continental seas and deep water," which continued till mid-Cretaceous days, when "a general elevation set in, resulting in the emergence of almost all the area which had been covered by the sea," until "at the beginning of the Cenozoic era the sea had abandoned all the center, parts of the south and north, and all the west of the country, but it still covered the northeast coast and southeast." Mexico then was a large peninsula with its point in the present "Central America," and of less size than now. Elevation in the early Eocene extended its limits to the east but part of this was again lost in the Miocene when an invasion on the west produced the gulf of California. At the end of the Miocene the peninsula of Yucatan emerged, and this elevation restored during the Pliocene, so much of the previous loss as to give to Mexico nearly its present form and size.

E. W. C.

Palæontologiska notiser, af GERHARD HOLM. Geol. Fören. i Stockholm Förhandl. Bd. 19, Hft. 3, 1897. In some palæontological notes by Dr. Gerhard Holm we find notice of the occurrence of the rare and peculiar fossil *Torrellella lævigata* Lnrs., at a new locality in Sweden. *Torrellella* is separated from the *Hyolithidæ* because of its phosphatic shell, and this shell, like that of the *Conulariidæ*, seems to have been exceedingly thin, for Holm says that the shell flattened in slate has only the thickness of paper.

Incidentally it is spoken of as connecting more closely the subfaunas of *Olenellus* (*Holmia*) *kjerulfi* and *Olenellus* (*Schmidtia*) *michwitzi*.

Holm discusses the relation of the two Olenelli above named and *Olenellus* (*Mesonacis*) *vermontana* and says that F. Schmidt's latest note on *O. michwitzi* shows that he finds it more closely related in pleura and pygidium to *O. kjerulfi* than he had at first thought. In the form of the glabella, however, to which Holm does not refer, there is a fundamental difference.

A second note by Dr. Holm describes the ectosiphon of a species of *Endoceras* (*E. burchardii* Dewitz). The species appears to have been described from drift fragments found in Germany, and so belongs to the Swedish Ordovician rocks. Dr. Holm says it agrees perfectly with A. Hyatt's group *Ellipochoanoida*. The article is illustrated with two cuts of examples of *E. burchardii* from the island of Oeland, and a figure of a fossil referred to the genus *Endoceras* (subgen. *Succoceras*) from Dalarna is also given. G. F. M.

Palæozoic Fossils, Vol. III, Part III, 4. The Fossils of the Galena-Trenton and Black River formations of lake Winnipeg and its vicinity. By J. F. Whiteaves. (Pp. 129-242, pls. 16-22, Ottawa, April, 1897.) The geology of lake Winnipeg and its vicinity has invited the attention of numerous explorers. The extensive collections made within recent years in that region by Dr. R. Bell, Messrs. T. C. Weston and L. H. Lambe, and the investigations of Messrs. Tyrrell and Dowling have brought to light the richness and beauty of the Lower Silurian faunas there preserved, and in the scientific portrayal of these, Dr. Whiteaves renders profound service to his science. In the last number of this volume of the *Palæozoic Fossils* the author gave a systematic list of all the species from the Hudson River formation of this region, and the present paper supplements this list with a similar one of all the other known species of the Lower Silurian in the lake Winnipeg district with the exception of certain stromatoporoids. The horizons especially represented are the entire Utica and Trenton formations inclusive of the Galena. A noteworthy feature of these faunas is the remarkable size attained by many of their species, a peculiarity which seems to be shared by all classes, if somewhat more strikingly exemplified in the Cephalopoda. The author cites *Receptaculites oweni* as attaining a diameter of 12-20 inches; *Streptelasma robustum*, 7 inches in length; the brachiopod, *Rafinesquina lata*, 3 inches along the hinge; *Maclurea*, 8½ inches in diameter and *Hormotoma*, 8 inches long; *Endoceras subannulatum*, 6 feet long and broken at both ends; *Poterioceras*, 7 inches in di-

ameter: shells allied to *Barrandeoceras*, nearly 2 feet across and fragments of *Isotelus gigas*, indicating a length of 20 inches.

Such general attainment of unusual size seems to the reviewer from the consideration of similar phenomena at other horizons, possible only on a deeply embayed coast where life conditions have been exposed to minimum infringement. J. M. C.

The morphology of the Graptolites has in recent years been the subject of much painstaking research. The results have been of great interest though the much discussed zoological affinities of these extinct organisms will hardly be regarded as yet determined.

Some of these late investigations have been largely directed to the determination of the conformation of the rhabdosome and the character of the cells or thecæ, and these have, for the most part, been based upon isolated mono- or diprionidian stipes preserved in their natural fulness in limestone matrix. Such are largely the studies by Holm, Wiman, notices of which have appeared in this journal: by Jaekel (Zeitschr. der deutsch. Geolog. Gesellsch, vol. 41), Perner (Études sur les Graptolites de Bohême, 1894) and Gürich (Zeitschr. d. d. geolog. Gesell. vol. 48, 1897). The work of Holm and Wiman has been most resourceful in the adaptation of various mechanical means to the development of material and the achievement of the objects sought. While these investigations have elucidated the conformation of the rhabdosome, the really remarkable discoveries of Ruedemann pertaining to the morphology of the entire colony in *Diplograptus*, as well as their development and mode of growth, have been based upon specimens preserved in the Utica shale which has been deposited under such conditions of quietude as to retain the colony without dismemberment.

Dr. Ruedemann's preliminary account of these discoveries appeared in the American Journal of Science for 1895 (vol. 19), while his completer paper, just issued, is in the Fortieth Annual Report of the N. Y. state geologist (1897), pp. 219-249, pls. 1-5, to which the reader is referred for a study of the author's remarkable illustrations. The fronds of these diprionidians are shown to be umbrella-shaped colonies, the component stipes of which radiating from a central disk, are not of the same length, in this unequal length evincing their unequal age. At the center, also, either above or below the central disk, is a quadrangular body which the author originally interpreted as a float or pneumatocyst similar to that of recent *Siphonophora*. With later evidence, a different function for this organ, now termed the basal cyst, is suggested, namely, a contrivance which secured the stability of the colony in the ooze of its habitat. Gonangia, which have been suspected and even alleged by other authors, are here clearly demonstrated, existing in a single cycle about the central disk and it is confidently asserted that the embryo graptolites, or siculæ, are observable within these gonangial sacks, attached by their apices to a central base. The analysis of these fossils demonstrates a near relationship between Diplograptus and the Sertularians, but upon the possession by the graptolites of the horny sheath in the embryo and the horny axis of the rhabdosome, it is proposed to place these organisms in a distinct and new class, the Rhabdophora.

The development of the colony from the embryo is thus summarized. "1. The detached sicula is provided with a basal appendage, to which it is attached by means of a little round node.

2. The node becomes a central disk and funicle. The sicula produces at first one theca, then a second, a third, etc.

3. With the budding of the first thecæ, the growth of the gonangia already begins, with usually four small capsules.

4. The further growth is marked by a remarkable lengthening of the hydrocaulus and a continued budding of thecæ at the proximal end of the primary rhabdosome, along the hydrocaulus and toward the center.

5. At last the gonangia mature and open. Many, or perhaps all of the siculæ, remain connected to the parent colony. The colony consists now of a rhabdosome, about half developed, which is the primary one, bearing a basal cyst, central disk and funicle, and on these, bundles of siculæ.

6. These siculæ grow out to rhabdosomes, the process beginning again with a lengthening of the hydrocauli.

7. After this first generation of rhabdosomes has reached a certain age, a second generation of gonangia begins to grow.

8. These latter open again and produce a new set of siculæ around the center. The colony consists now of the primary rhabdosome, a verticil of young rhabdosomes, and another of siculæ. This process is continued, the successive generations of gonangia producing siculæ which in turn develop into verticils of rhabdosomes." J. M. C.

The Bulletin of the Museu Paraense (Para, Brazil), which has completed its fourth number, gives gratifying evidence of the vitality of that institution. Its papers on the general natural history and ethnology of the state of Para and of Brazil generally, are of extraordinary interest and make a very creditable showing for this young museum and its industrious director, Dr. Emilio Goeldi. Dr. F. Katzer, who is widely known for his "Geology of Bohemia," has recently been appointed chief of the geological section, and contributes to volume 1, no. 4, October, 1896, an interesting paper on the oldest fossiliferous beds of the Amazon region. Rocks of middle or upper Silurian age were discovered along the Rio Tromketas by the Morgan expeditions and their fossils have been identified by Hartt, Derby, and pretty fully described and illustrated by Clarke. Katzer now records the occurrence of graptolites along the Maecurie river, where, heretofore, only Devonian rocks have been recognized. Associated with them are masses of hexactinellid sponge spicules. The graptolites are not particularly described, but their presence may be regarded as indicating lower or upper Silurian rocks in that region. Hexactinellid spicules have been observed by Clarke in the middle Silurian of the Tromketas, but graptolites have not before been reported from Brazil. J. M. C.

Ueber Dictyonema cavernosum, n. sp., von KARL WIMAN. (Bull. Geol. Instit. of Upsala, No. 5, Vol. III, 1896.) The description of this species which is very full is based on material prepared by the new methods

used of late by the Swedish, German, and some English observers, which have yielded such excellent results with the Rhabdophora. In accordance with his view of the life history of individuals of the above genus Herr Wiman shows in *D. cavernosum* the presence of three kinds of individuals in the rhabdosome, viz., nourishing individuals, budding individuals, and sexual individuals, or gonangia.

The article has four figures, mostly prepared sections of individuals of this species showing the mode of growth and a plate showing portions of the rhabdosome natural size and enlarged, and sections of the cells further magnified. G. F. M.

Kambrisch-silurische Faciesbilgungen in Jemtland, von KARL WIMAN. (Bull. Geol. Instit., Upsala, No. 5, Vol. III, 1896.) The aspect of the Cambro-Silurian formation (terrane) of Jemtland as shown by this account of studies made in that province, differs considerably from that of the formation in southern Sweden, notably in the absence of the older part of the series. In the conglomerates at the base *Eurycare latum* is the oldest type of trilobite found, so there would appear to be no recognizable Cambrian portion; even Olenus (sens. strict.) seems wanting. This is in accordance with facts observed elsewhere in northern Sweden where the land was not submerged so early in Cambrian time as it was in the south.

The gray southern limestone is said to conform more closely in aspect to the Norwegian type than to that of southern Sweden: and this not unnaturally seeing that the western Cambrian areas in Jemtland lie along the Norwegian borders and are not more than forty miles from the Atlantic. Dark shales prevail in the central part of the province, but quartzites both to the north and south. This Cambrian tract in Jemtland is opposite where at the Trondhjem fjord the Atlantic nearly cuts across the Norwegian mountains.

The paper is illustrated with a number of sections, two plates and a map of the Cambro-Silurian of Jemtland. G. F. M.

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oölite limestone of Indiana, T. C. Hopkins and C. E. Siebenthal; Geology of Vigo county, Indiana, J. T. Scovell.

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Proc. Iowa Acad. Sci., vol. 4, (1896), 242 pp., 26 pls., 1897. Memorial of Charles Wachsmuth, C. R. Keyes; The State quarry limestone, S. Calvin: Stages of the Des Moines, or chief coal-bearing series of Kansas and southwest Missouri and their equivalents in Iowa, C. R. Keyes; Vertical range of fossils at Louisiana, C. R. Keyes and R. R. Rowley; Natural gas in the drift of Iowa, A. G. Leonard; Results of recent geological work in Madison county, J. S. Tilton: Drift section at Oelwein, Iowa, G. E. Finch; Evidence of a sub-Aftonian till sheet in northeastern Iowa, S. W. Beyer; A pre-Kansan peat bed, T. H. Macbride; Summary of discussion (on drift of Iowa), S. Calvin; Additional observations on surface deposits of Iowa, B. Shimek.

III. Papers in Scientific Journals.

Science, June 18. Current notes on physiography, W. M. Davis.

Ibid., June 25. Is the loess of either lacustrine or semi-moraine origin? J. E. Todd.

Ibid., July 2. Origin of Green river, S. F. Emmons: Current notes on physiography, W. M. Davis.

Ibid.. July 16. Pleistocene fossils from Baffinland and Greenland, E. M. Kindle,; Current notes on physiography, W. M. Davis.

Ibid., July 23. New terms in geology, J. C. Branner; Notes on some fossils of the Comanche series, F. W. Cragin.

Ibid., Aug. 6. Current notes on physiography, W. M. Davis.

Ibid.. Aug. 13. Edward Drinker Cope, naturalist--a chapter in the history of science,—Theo. Gill.

Ibid., Aug. 20. Current notes on physiography, W. M. Davis: The antecedent Colorado, M. S. W. Jefferson.

Bull. Amer. Geog. Soc., vol, 29, no. 2, 1897. Mountain structures in Pennsylvania, A. P. Chittenden.

Technology Quart., vol. 10, no. 2. June, 1897. Glacial observations in the Umanak district, Greenland (Scientific work of the Boston party of the sixth Peary expedition to Greenland. Report B), G. H. Barton.

Mining, June, 1897. Principal features of the geology of southeastern Washington (Abstract), I. C. Russell.

Amer. Antiquarian, May and June, 1897. The Tertiary man, H. W. Haynes.

Amer. Naturalist, Aug. New observations on the origin of the Galapagos islands, with remarks on the geological age of the Pacific ocean, G. Baur.

School of Mines Quarterly, April. An introduction to the study and experimental determination of the characters of crystals, A. J. Moses.

Amer. Jour. Sci., July. Ctenacanthus spines from the Keokuk limestone of Iowa, C. R. Eastman; Identity of chalcostibite (wolfsbergite) and guejarite, and on chalcostibite from Huanchaca, Bolivia, S. L. Penfield and A. Frenzel; Interesting case of contact metamorphism, H. W. Fairbanks: Tin deposits at Temescal, Southern California, H. W. Fairbanks; Outlying areas of the Comanche series in Oklahoma and Kansas, T. W. Vaughan; Monazite from Idaho. W. Lindgren.

Ibid., Aug. Tamiobatis vestustus--a new form of fossil skate, C. R. Eastman: Florencia formation, O. H. Hershey; Native iron in the Coal Measures of Missouri, E. T. Allen: Bixbyite. a new mineral, and notes on the associated topaz, S. L. Penfield and H. W. Foote: Composition of ilmenite, S. L. Penfield and H. W. Foote: Igneous rocks of the Leucite hills and Pilot butte, Wyoming. Whitman Cross; Stylolites, T. C. Hopkins; Extinct Felidæ, G. I. Adams.

Journ. of Geol., July-Aug, Moraines of recession and their significance in glacial theory, F. B. Taylor; The eruptive rocks of Mexico, O. C. Farrington; The stratigraphy of the Potomac group in Maryland, W. B. Clark and Arthur Bibbins; Studies for students—Comparative study of palæontogeny and phylogeny, J. P. Smith.

IV. Excerpts and Individual Publications.

Papers and notes on the genesis and matrix of the diamond by the late Henry Carvill Lewis, edited by T. G. Bonney. xvi and 72 pp; 2 pls.; Longmans, Green & Co., New York, 1897.

Abraham Gesner, a review of his scientific work, G. F. Matthew. Nat. Hist. Soc. of New Brunswick, Bull. 15, pp. 1-48, 2 maps, 1897.

On the fossil phyllopod genera, Dipeltis and Protocaris, of the family Apodidæ, Charles Schuchert. Proc. U. S. Nat. Mus., vol. 19, pp. 671-676, pl. 58, 1897.

Relations of the Wisconsin and Kansan drift sheets in central Iowa and related phenomena. A dissertation presented to the faculty of arts, literature and science of the University of Chicago in candidacy for the degree of Doctor of Philosophy. By H. Foster Bain. Pp. 5-52, 2 maps; The University of Chicago Press, 1897.

The clays and clay-working industry of Colorada, Heinrich Ries Trans. Amer. Inst. Mining Eng., Lake Superior meeting, July, 1897; 5 pp.

The Fuller's earth of South Dakota, Heinrich Ries. Ibid.; 3 pp.

Gold deposits of Georgia, S. W. McCallie. Read before the International Gold Mining convention at Denver, July 8, 1897; 17 pp., 1 map. Atlanta, 1897.

Description of an extinct Palæozoic insect, and a review of the fauna with which it occurrs, G. F. Matthew. Nat. Hist. Soc. of New Brunswick, Bull. 15, pp. 49-60, pls. 1-2, 1897.

The stone industry in 1896, W. C. Day. U. S. Geol. Survey, 18th Ann. Rept., pt. 5, pp. 1-126, 1897.

A syllabus of physical geography, C. W. Hall and W. F. Kunze. 55 pp., Minneapolis. The University Book Store, 1897.

President's address to the geological section of the British A. A. Sci., 1897, (Ancient Rocks of Canada), G. M. Dawson. 13 pp.; Toronto, 1897.

Ice-jams and what they accomplish, M. A. Veeder. 8 pp.; read before the A. A. A. S., Aug. 13, 1897.

A catalogue of minerals alphabetically arranged, with their chemical composition and synonyms, A. H. Chester. 4th ed., 56 pp.; New York, John Wiley and Sons, 1897.

V. Proceedings of Scientific Laboratories, etc.

Kansas Univ. Quarterly, ser. A, vol. 6, no. 2, April, 1897, Brachysaurus, a new genus of mosasaurs, S. W. Williston; On the extremities of Tylosaurus, S. W. Williston.

Field Columbian Museum, pub. 18, geol. ser. vol. 1., no. 2, pp. 67-120, pls. 7-18, April, 1897. Observations on Popocatapetl and Ixtaccihuatl, with a review of the geographic and geologic features of the mountains, O. C. Farrington.

CORRESPONDENCE.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. The forty-sixth annual meeting began at Detroit on August 9th. The death of Prof. Cope left the Association without a president and the vice-president, W J McGee took his place. After the usual preliminaries of the Association the sectional meeting began. By previous arrangement it had been settled that the geological section should suspend its meetings on Monday and Tuesday in order to afford the geological society an opportunity to hold its meeting. Consequently after the general session on Friday the latter society met, with Prof. E. Orton, the president in the chair, and the proceedings opened with a paper by Prof. Simonds of the University of Texas, on the granite area of Burnet county in that state. In this an account was given of the granite quarries and bosses found on the Colorado river near the junction of the Llano. The rock contains feldspar, clear and milky quartz, and biotite mica. The speaker after describing the country and its rocks entered on a comparison of the different opinions of Walcott, Hill, and Comstock regarding the age of this granite, and concluded in opposition to most previous writers that it is of post-Carboniferous and possibly of Cretaceous date.

Mr. Bayley Willis followed with a paper on the Eocene and Miocene freshwater deposits of Washington. After describing the strata of that age on Puget sound, 5000 to 7000 feet thick, he showed how these had been folded, faulted and overthrust, as have the Paleozoic beds of the eastern part of the continent. The compressing however in the present case acted from the west instead of the east. During the consequent movement the coal beds acted as a slide and the roof slipped over the floor, crushing the coal to powder and leaving rounded masses in the midst of it. The coal varies from lignite with twelve per cent. of water to good steam coal with only three per cent. and this proportion of water is in inverse relation to the amount of disturbance that has taken place.

The loess as a land deposit was the subject of a paper by J. A. Udden of Rock Island. The writer took the wide view of the loess, including in it all forms and conditions of this material—that in the river valleys and that at all altitudes—and maintained that it was all due to wind-action and was an accumulation of dust carried in the atmosphere. He argued that its lack of assortment was conclusive proof that it was not of aqueous origin. This view of the subject was strongly combatted by some members who considered that the loess was due not entirely to a single agency.

Dr. J. W. Spencer presented a paper on the relation between submarine valleys and land declivities. He argued that the sea bottom was usually the continuation of the land surface under water and illustrated the doctrine by quoting the extension of submarine river valleys out to sea chiefly in the Antillean region. Their contours he argued proved an elevation of 8000 to 10000 feet in that region. Thus the Mississippi val-

ley was continued out into the gulf of Mexico and two buried channels run east and west from cape Sable, the former being called the Bahaman and the latter the Floridan. Over the col between the two flows the gulf stream.

In a second paper Dr. Spencer described the geology of Mexico and from recently published maps of that country took occasion to point out that the coast plateau is a continuation of that of Texas and rose to the hight of 1700 feet. It is of Lafayette and Columbian date. The central cretacean plateau rises to 8000 feet and forms the largest area. The isthmus of Tehuantepec now reaches a hight of only 800 feet and was in late Pliocene and early Pleistocene times completely submerged allowing passage between the two oceans. The last conclusion is warranted by the resemblance between the shallow water faunas of the two sides of the isthmus while the inhabitants of greater depth show little resemblance. The Pliocene strata have in some places been elevated to a hight of 8000 feet.

Prof. F. B. Taylor took up the controverted subject of Niagara and advocated the view that the wide portion of the gorge below the whirlpool and a small part of that above it was cut by the river immediately after the retreat of the ice and when the whole water of the lakes was poured over the cataract—that the narrow part above is the work of the smaller stream when part of the water was drawn off by the Nipissing outlet into the Ottawa river, and that the wider portions from the cantalever bridge to the present falls is due to the greater body of water ensuing on the uplift and closing of that outlet. Some discussion followed partly in favor of Mr. Taylor's views and partly in opposition.

In a second paper Mr. Taylor pointed out a possible, now extinct, channel from the Georgian bay to the river Trent by way of lake Simcoe, also dependent for its existence on the closing of the Nipissing channel.

The last paper read was by Mr. W. H. Scherzer of Ypsilanti, Mich., and gave a clear and interesting account of the strata in the vicinity of Detroit. It concerned chiefly Monroe and Wayne counties. Large quarries of the Corniferous limestone expose about 15 acres of the rock, which has been quarried to a depth of 30 feet, the whole thickness being 100-150 feet. It contains much chert. The Onondaga and Waterlime together reach 2000 feet and are very barren of fossils. The latter contains beds of the peculiar Sylvania sandstone of the Ohio survey in which occasional fossils have been found—the only case on record. The minerals of the Lower Helderberg are celestite and calcite in pockets, and sulphur of which 200 barrels have been taken out within two years. The most valuable mineral is the salt of the Onondaga group of which 3 beds exist near Detroit, the topmost at the depth of 800 feet, the second at 1200 feet and the third at 1800 feet. They have a combined thickness of 600-700 feet, including gypsum and shales interbedded. They thin away to the south and disappear within a few miles.

The society then adjourned to meet next May as Section E of the A. A. A. S.

The following papers were read by title:

Notes on the geology of the lower peninsula of Michigan, ALFRED C. LANE.

The nomenclature of the Carboniferous formations, ROBT. T. HILL.

Ice-transported boulders in coal seams, E. ORTON.

Clay veins vertically intersecting coal measures, W. S. GRESLEY.

SECTION E, A. A. A. S. Vice-president I. C. White was absent having gone to St. Petersburg to attend the International Congress of Geologists. Prof. E. W. Claypole of Akron, O., was elected by the section to fill his place as chairman. Prof. White had sent his address which was read by Prof. Claypole. It treated of the Pittsburgh coal bed detailing the character of this vast mass of mineral fuel, and giving sections of it at various places to show its regular structure many miles from its typical exposure. The persistency of the very thin shale partings only a quarter of an inch in thickness over many hundred square miles of country is exceedingly striking and characteristic. Prof. White also pointed out the important discovery that this sheet of coal is missing over 5000 or 6000 square miles where it has been hitherto presumed to be present. Its whole area is thus reduced very largely and the Appalachian coal stores lessened to an equal extent.

Prof. F. B. Taylor pointed out to geologists visiting Detroit some of the leading features of its surface geology. Reviewing previous work he dwelt on the previous condition of the lake region when it was covered with a single sheet of water of various extent at different dates—Warren water and lake Algonquin being especially mentioned. Passing on he urged that the last movement about Detroit had been one of depression as evidenced by the deep water in the streams entering the river which is out of all proportion to their breadth. Generally speaking he considered that their beds had been cut down to a level about 30 feet below the present. Mr. Taylor made arrangement to guide some of the geologists in a short excursion to examine a few of these deep channels that could be seen in the city of Detroit.

Prof. Spencer reviewed at some length the researches made in the Niagara district giving historically a sketch of the contributions of all who had taken an active part in the work and stating the present condition of its chief unsolved problems. Mr. Gilbert gave the evidence obtained by himself and others regarding post-glacial changes of level in the region and entering into detail showed that by measurements made as accurately as the conditions allowed, he had provisionally demonstrated an elevation of $\frac{3}{4}$ of an inch at Sackett's harbor as compared with Charlotte in 20 years, one of 3 inches at Port Colburn as compared with Cleveland in 37 years, one of $1\frac{1}{2}$ inches at Point Austin as compared with Milwaukee in 20 years, and one of 2 inches at Escanaba as compared with the same. Generally he inferred at these four stations the following conclusions: that in 100 years the rate of elevation was 37, 66, 39 and 46 feet respectively. Following these results into more detail he advanced to prophecy and said that if the results above given were actual and con-

tinuous the outlet of the lakes through Chicago would eventually be restored and that at Niagara dried up, that in 1000 years water would begin at times to flow over this ridge and would be continuous in 1500 years, that in 2000 years the stream would equal Niagara, that in 2500 years Niagara would intermit, and in 3000 years would cease altogether.

Prof. Chamberlain resumed the consideration of loess and in substance agreed with previous speakers in the opinion that it was not due to aqueous or to æolian origin entirely but that both had been concerned in the work. It graduated he said in some places into glacial clay and passed below into coarse sand becoming finer also as it recedes from the edge of the ice sheet and from the border of the rivers. The great elevation which it reached—1000 feet above sea level in some cases—excludes water as the sole depositing agent. The suggestion was accordingly made that much of the material had been blown up the gentle glacio-fluvial slopes and deposited upon the higher levels. This of course implies a dry time. The demarkation of the loess due to the two agencies is difficult, perhaps impossible, but one of the chief efforts of geologists working in the region should be to discover marks of differentiation between the deposits and so learn how to distinguish them.

Prof. Albert Penck of Vienna, being called upon by the chairman, responded with a brief account of the loess in its typical region, the European Alps. He would approve the view of its double origin and said that the same conclusion had been reached in Europe. He regarded the loess as peculiar to the northern portion and said that it did not occur on the south side of the Alps, where he also added there was evidence of recent depression which was lacking on the north.

The section concluded its meeting on Thursday afternoon, leaving Friday free for various short excursions to local points of interest. On Saturday a general excursion to the St. Clair flats was announced and that arrangements had been made for those members of the Association who desired to do so to attend the meeting of the British Association at Toronto, beginning on the 18th of August.

The unsolved and interminable problem of Niagara was taken up by Prof. F. B. Taylor who attempted what may be called a correlation of the views of geologists regarding this gorge and the retreat of the ice. After sketching rapidly the circumstances attending the formation of the Niagara river he called attention to the difference in width of the chasm at different places and explained it by the theory that it was due to the varying quanity of water going down the river. In the earliest stage the water of the whole system of the four lakes united passed over the falls. Then for a time an outlet was opened by the Nipissing valley into the Ottawa and only the water of lake Erie such as it then was came in this direction. Later by an uplift of the land this outlet was closed and the whole drainage again sent over Niagara. During the former of these intervals Mr. Taylor thinks that the narrow channel between the cantalever bridge and the whirlpool, except the lower 400 yards, was excavated and the wider portions above and below these points by the greater river of earlier and later time. Mr. Taylor also briefly referred

to a temporary channel through lake Simcoe for the drainage of the Georgian bay while the district to the northward was occupied by a lake of the glacier.

Prof. H. F. Osborn gave an address on a new region of vertebrate fossils in the west which he has named the Huerfano. It is in the horizon of the Lower Eocene and Prof. Osborn has divided it into a lower, middle and upper portions. The first and second are contemporaneous with the Puerco, Green River and Wachsatch, and the third with the Bridger beds of the Tertiary. Like others they are the freshwater deposits of an ancient lake into which were washed the relics of the surrounding fauna. The thickness of the shale is 8000 feet and the beds overlie the laccolites of Silver mountain and Spanish peaks. The fossils of the beds were not described.

"The Chicago Outlet" was the title of an address by Mr. Frank Leverett. The substance of Mr. Leverett's contribution, which was recently printed by the Chicago Academy of Science was as follows. The outlet was the channel of escape for the waters of a lake which existed during the ice age and for which the name of lake Chicago has been proposed. This channel led from the Michigan basin by a double course around the site of the present city and is cut chiefly through soft morainic and other glacial material, but to a slight extent in the limestone rock. Mr. Leverett described two stages in the history of lake Chicago, marked by distinct beaches.

Prof. W. N. Rice presented a review of the various theories regarding volcanic action and expressed his preference for that which was based on the view that the viscid core of the earth was kept solid by pressure and that the local relief of this pressure caused liquefaction of the material which was followed by outflow.

Mr. Parmelee presented a few notes on the minerals of Cripple Creek, Col., and spoke particularly of an ore of gold consisting largely of tellurium which was separated by heat as telluric acid. He showed a small but very nearly perfect crystal of this compound.

A very remarkable coral from the Hippurte limestone of Jamaica was described at length with specimens and illustrations by Prof. R. P. Whitfield of New York. *Barrettia monilifera* is a massive form, the specimen shown being about 18 inches long by 8 inches in diameter. It is calyptrate and the genus has been mistaken by previous writers working on less perfect examples for a bivalve mollusc. Full details cannot be given here but will appear in the Bulletin of the N. Y. Museum of Natural History.

Two other papers, one on "Ice-jams and their glacial effects," and the other on "Carboniferous strata of Michigan," closed the program.

Few of the foreign geologists were present at Detroit. Prof. Penck of Vienna, already mentioned, Prince Kvapotkine from Kent, England, and Dr. H. P. Truell from Wicklow, Ireland, were present at several of the sessions.

A joint session of the sections of geology and geography was held on Wednesday afternoon to hear and discuss several papers on ancient man

in the Delaware valley. After a few notes by Messrs. Knapp and Kummell, Prof. Putnam reviewed the work of the past 20 years by Dr. Abbott and others and the various views that have been held regarding its results. In order to attempt a decision on some of these points several geologists met at Trenton in June last to make a careful examination of the ground. Prof. G. F. Wright stated that the results obtained did not materially differ from those previously obtained. They were therefore claimed in part by both sides of the controversy. The ground is a farm belonging to the Misses Lalor, who have become much interested in the investigation and have allowed the archæologists to dig it over at their own will and excluded all others. Much discussion took place on the mode of deposit of the sands overlying the true and undisputed glacial gravel, some maintaining an æolian and others an aqueous origin.

Prof. Holmes followed and dwelt strongly on the results which attended his own search of the material thrown out of a trench, in which as he has already stated in print, he was unable to find any trace of man. He urged the disturbances to which the ground had been subjected and maintained that it had extended to a much greater depth than was generally allowed and in consequence of this he considered the implements as intrusive.

A short paper by H. C. Mercer was then read, giving an account of some trenches which he had recently dug, but which again contributed nothing of noveltry or importance. The same may be said of the note contributed by Thos. Wilson, while Prof. Salisbury took strong views against the glacial date of the sand beds overlying the undurated glacial gravels of the valley. Prof. Salisbury's views on the subject are well known and he asserted that nothing had occurred to change them. He detailed at some length the geology of the valley and stated his belief that the date of the sands in question was indeterminate. An active but entirely friendly discussion followed, in which Prof. Penck of Vienna, Profs. Chamberlin, Wright. Putnam, Claypole, and others took part. Prof. Putnam stated in addition to his former remarks that a human skull had been found in the excavation for a new gas meter at Trenton at a depth of 13 feet but had not yet been examined carefully.

The discussion was animated and long, the session continuing until nearly 6 o'clock.

The Toronto meeting of the British Association for the Advancement of Science opened on Wednesday, August 18 and continued during the whole week. The president of the year is Sir John Evans and the section of geology was presided over by Dr. Geo. M. Dawson. The section met in one of the many buildings scattered over the spacious grounds of the University of Toronto. The main building which has risen from the ashes of that in which the American Association met a few years ago and which was unfortunately burnt down soon afterward, is a handsome stone structure about 300 feet in length in front and forming three sides of a triangle. Here were housed the general officers of the Association and some of the sections.

In the geological section several important petrographical papers were presented. Messrs. Barlow and Ferrier illustrated the structure of a small area of granite which they had recently studied, with a series of lantern slides showing a peculiarly increasing amount of chemical metamorphism and at the same time a slowly rising rate of movement among the particles of the rock. Mr. Miller spoke of the presence of very small amounts of nickel in some of the Canadian iron ores, and discussing the merits and demerits of the titaniferous ores he suggested that possibly some of the useful properties attributed to the titanic iron might be rather due to the small amount of nickel contained in them.

Mr. J. B. Tyrrell laid before the section an account of the recent work of the Dominion survey on the different ice-sheets of Canada. He said that evidence showed that the earliest to form was the Cordilleran on the Rocky mountains and that its ice spread over the plains to the east carrying drift outward from that range as a centre in all directions. On the retreat of the Cordilleran glacier the Keewatin ice-sheet advanced from the region west of Hudson bay and overspread all the north-central part of the country, extending down far into the United States. This was subject to several recessions and before its final retreat the third ice-mass advanced from the Labradorian region and became conterminous with the Keewatin, holding behind their united points the glacial lake Agassiz. Finally both receded and the post-glacial period began.

Mr. John Milne gave a most interesting summary of his recent report on the volcanoes of Japan, to summarize which here is quite impossible. Many of the details given were also announced in the evening lecture, which will be mentioned later.

Mr. Seward of Cambridge discussed the relation of the Carboniferous genera Bennettites and Williamsonia, and from a study of their structure and a comparison with other forms had been led to the conclusion that the two really form but one genus.

Prof. Fairchild gave at length a view of the condition of the surface geology round the region of the finger lakes of New York, giving the views of the geologists who have written upon the subject and sketching the glacial history of the region.

Prof. F. D. Adams followed with a petrographical paper discussing the nature of some of the gneisses and gneissic rocks of the Grenville series of Canada. He showed the close agreement in ultimate analysis between some of them and certain shales and argued that the former were only highly metamorphosed forms of the latter.

In an address illustrated with lantern slides, Dr. E. W. Claypole sketched the palæozoic geography of the eastern United States and in a series of maps showed the varying forms of the continents and seas as Silurian and Devonian times passed by. The principal feature was an elevation of the southern portion, which progressed through Silurian and Devonian times until it came to an end and an opposite motion set in during the upper Devonian sub-era.

The evening lectures constitute a very interesting and useful part of

the meeting, being usually given by men who are thoroughly familiar with the subject down to the most recent developments and who are also able to impart to it that element of life which is essential in a popular address. They are calculated to diffuse a knowledge of science among the general public. Prof. John Milne spoke on the subject of earthquakes on which he is a past master. Discarding all other views he fixed the attention of the house on the modern doctrine that the earthquake is only the result of a slip of the strata along a line of crack or fault, which produces a wave or vibration whose emergence at the surface causes the tremor or the quake. He illustrated his difficult theme by many striking examples showing that these waves are transmitted not only through the superficial strata but also through the solid globe so that after a certain distance from the epicentre is reached the vibration arrives at all parts of the surface at very nearly the same instant. He described the methods of observing earthquakes and very briefly some of the instruments employed, and told the audience that from his own observations made in England he had announced to the British Association on August 31, 1896, that news would come of a severe earthquake in Japan at a certain instant. In due time this prediction was verified, the actual time being one minute later than his prediction.

Passing to submarine disturbances, Mr. Milne mentioned that they frequently caused the breakage of the telegraphic cables, and where examination was made it was constantly found from soundings, that an extensive landslide had taken place, burying the wires so that the only way of repairing them was by dragging until they broke and abandoning the buried portion. In one case the depth was increased 200 fathoms and in another, three of the Atlantic lines 10 miles apart were broken at the same moment showing a slip of 20 metres in length. Prof. Milne showed a number of slides, some of which were very striking, as illustrating the mode of destruction suffered by railroad tracks, girder bridges and other structures during an earthquake. He explained the economic value of the study and showed how the principles of engineering followed in stable countries must be modified in Japan and how by years of study he and his colleagues had succeeded in establishing data and laying down rules for seismic construction whereby even tall chimney stacks can be erected with safety and will sway to and fro without falling during a shock.

Prof. Robert Austin lectured on "Canada's Metals" and enlarged on the enormous stores of these which exist in the Dominion. The nickel mines of Sudbury can supply the market of the world, and more cheaply than any other, inasmuch as the copper obtained as a by-product pays the cost of the smelting, leaving the other metal as pure profit.

He showed some striking experiments with the electric furnace in which the audience could see projected on the screen such metals as gold rapidly fusing and falling in that condition from the ends of the bars.

The presidential address, as might be expected from the well known tendency of the author, Sir John Evans, was archæological in its na-

ture. It consisted largely of a general review of the history of the doctrine of the antiquity of man in Europe. In some respects the views of the speaker were at variance with those of geologists on the subject, but the geological side of the question was very slightly touched.

The points on which stress was laid were the immense antiquity and wide dispersion of palaeolithic man and the clear and sharp distinction between his works and those of neolithic man. The speaker enlarged on the importance of preserving the traces and relics of the fast disappearing savage races of the earth, and eulogized the efforts of the governments of the United States and of Canada in so doing.

On Monday afternoon the section of geology adjourned in order to visit the remarkable glacial and interglacial deposits at Scarborough Hights, under the guidance of Mr. Coleman and Dr. Spencer. These beds reach a thickness of about 300 feet above lake Ontario, and contain at least two beds of glacial clay and stones with interbedded fossils, fishes, sand and shales. They are cut through and exposed by several gullies which reveal their structure from top to bottom. They are regarded as the estuarine deposit of a great river emptying into the lake in interglacial time and at various dates.

Shortness of time prevents giving a full account of this meeting. We hope to complete it next month.

A joint session of section C (Geology) and I (Anthropology) was held on Wednesday morning to take up the subject of the antiquity of man in eastern North America. The chief speakers were Prof. F. W. Putnam and Dr. E. W. Claypole. The former gave a summary of the evidence already at hand regarding the implements found in the Trenton gravels concerning which the dispute has been so long and complicated. The latter gave a rapid account of the evidence in the recent case of the discovery of the Masterman axe at New London, Ohio. As both these are already before the readers of this magazine it is unnecessary to restate them at length. (See AM. GEOL., Nov., 1896.) An animated discussion followed in which Sir John Evans, G. M. Dawson, Dr. Spencer, Mr. McGee and others spoke. Prof. Putnam and Claypole replied. A somewhat guarded tone was observable during the discussion and both sides kept carefully within the lines of the evidence and the argument.

INTERNATIONAL GEOLOGICAL CONGRESS.

GUIDE TO THE EXCURSIONS. The committee of the seventh International Congress, now meeting in Russia, have issued a most comprehensive guide for their visitors from abroad. No one on looking at it will be at all surprised that it failed to appear exactly on time. The thanks of all, both those who went and those who stayed, are due to the thoughtfulness of their Russian collaborators in geology for this detailed and beautifully arranged volume.

It contains about 500 pages of letterpress and numerous illustrations. An excellent geological map of Russia in Europe is contained in a packet at the end of the volume. It is on the scale of 1:6,300,000 and shows

clearly in lettered colors the systems and groups of the Empire. It is from the press of A. Illyne, St. Petersburg.

The volume consists of 36 separate essays on the geology of the regions visited by the members, both before and after the meeting. They are fully illustrated with outline and colored maps, sections, tables, and reproductions of photographic views. It would be invidious to select from material of so valuable a nature, but the names of those who have borne the brunt of the work in arranging for the meeting of course figure largely in the list.

Every essay is separate and separately paged and by an excellent plan all are held firmly together, by a spring cover which can be loosened in a moment and any one of the whole taken out for use. In this way the members can from day to day select the essays needed without burdening themselves with the whole volume, which weighs several pounds.

Five of the essays are in German and all the rest in French, the official language of the Congress. The typography and execution are excellent, distinct and sharp, the illustrations well done and the misprints exceedingly rare. It is perhaps superfluous or even impertinent to congratulate the Russian committee on the excellence of the "guide" since they have evidently set out with the intention that it should be as good as it could be made and for this end the intellectual part of the work has been ably supported by the mechanical. But we may certainly be allowed again to express our thanks to our Russian brethren in geology for the unstinted labor and care that they have expended on all parts of this monumental guide to their European dominion and to express the hope that they will derive some compensation from the pleasure and profit which they have given both to those of their foreign friends who are with them in person and to those also who would be there if they could. E. W. CLAYPOLE.

PERSONAL AND SCIENTIFIC NEWS.

PROF. C. L. HERRICK, late one of the editors of the AMERICAN GEOLOGIST, has been elected president of the University of New Mexico, at Albuquerque.

DR. C. H. GORDON, of the geological department of the University of Chicago, is about to sail for Europe where he will spend six or eight months in study and travel. Mail addressed to Valley Center, Michigan, will reach him promptly.

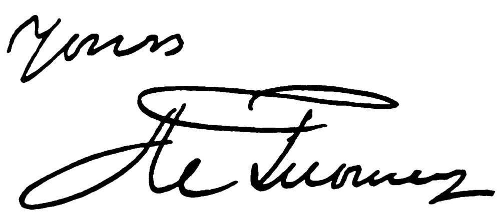
MR. WARREN UPHAM returned to America, Aug. 28th, by the steamer St. Louis. With his wife he has visited Great Britain, Scandinavia, Denmark, Hamburg, Berlin, the Alps, and Paris. Besides a review of some features of Pleistocene geology he has made special study of the organization and administration of some of the great public libraries.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE at its recent meeting in Detroit elected F. W. Putnam of Cambridge president, and L. O. Howard of Washington permanent secretary. The vice-president of section E (geology and geography) is H. L. Fairchild of Rochester, and the secretary is Warren Upham of St. Paul. The next meeting, the fiftieth anniversary of the Association, will be held in Boston.

CAPE OF GOOD HOPE. The first (1896) annual report of the Geological Commission has recently been published. Besides the official reports it contains short papers on special topics, a map of the dolerites of Eastern Nieuwveld and a sketch plan of the Congo cave. The staff is as follows: G. S. Corstorphine, geologist: A. W. Rogers and E. H. L. Schwarz, assistant geologists; H. P. Saunders, secretary.

U. S. NATIONAL MUSEUM. On the recommendation of Hon. Chas. D. Walcott, acting assistant secretary of the Smithsonian Institution, in charge of the U. S. National Museum, an important change has been made in the administration of the Museum. Three sections have been organized—a section of anthropology, a section of biology and a section of geology, each having a head curator with an annual salary of $3,500. Dr. W. H. Holmes has been appointed head curator of anthropology; Dr. Frederick W. True, head curator of biology, and Dr. G. P. Merrill, head curator of geology. Dr. True and Dr. Merrill are already connected with the Museum, and it is expected that Dr. True will continue to act as the executive curator. Dr. Holmes leaves the Field Columbian Museum, Chicago, to accept this position, but was formerly connected with the U. S. Geological Survey and the Bureau of Ethnology (*Science*.)

THE MARYLAND GEOLOGICAL SURVEY has just issued its first volume, which is a very attractive report of over 500 pages and numerous maps. The second volume, which will contain a description of the building and decorative stones of the state, is well advanced and will be issued the coming winter.



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Vol. XX, Plate XIV.

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SKETCH OF THE LIFE OF MICHAEL TUOMEY.

By EUGENE A. SMITH, University of Alabama.

(Plate XIV).

Practically all that is known concerning the early life of Prof. Tuomey, has been brought together by Rev. R. D. Nevius, of Tacoma, Washington, in an article published soon after Prof. Tuomey's death in the Alabama Educational Journal. The following sketch is a condensation from this article, supplemented by some remarks concerning his eminence as a teacher, and as a geologist, and an annotated list of his scientific writings. The accompanying portrait is from a daguerreotype taken a short time before his death, and is considered by all who knew him an admirable likeness.

MICHAEL TUOMEY was born in Ireland, in the city of Cork, on St. Michael's day, 1805. His father, Thomas Tuomey, was a highly respectable man of industrious habits and of no inconsiderable mechanical skill. His mother, Miss Nora Foley, was descended from a noble family. He was educated chiefly at home* and at his grandmother's in the country, where he spent much time in his early years. From his grandmother, who seems to have been in many respects a remarkable woman, he received his first impulse towards the study of botany, which he never intermitted, and in which he was always an

*Prof. Tuomey studied Latin and French, and to some extent German also, after he came to America.

enthusiastic and a proficient student. Nor was his mother less careful to instruct his taste in the study of beautiful views and landscapes. It was in these studies and amusements, no doubt, that he formed that habit of close observation in every department of science for which he was always distinguished, and here, no doubt, began an education in taste that afterward became sensitively and even severely correct.

With no other education than this,* so far as is known, he went from home at seventeen years of age, and joined a friend in teaching a school in Yorkshire, England; and from this early period his own genius was his only monitor, and his own powers his only support; while his habit of minute observation, wedded to his native genius, was to him the one smooth stone with which, in a firm reliance upon himself under God, and a modest demeanor which won for him the favor of man, he went forth like David, not indeed against an enemy, but into a department of learning whose difficulties were like a giant in his way.

It is not certain, however, that he entered upon the study of that science in which he made greatest progress, in any other way than as an amateur, until, after giving up his school in a few months, he came to America. The exact date of his coming is not known. He remained several months in Philadelphia, after which he purchased a small piece of land in Pennsylvania, and with a gentleman he induced to accompany him, he entered into possession of an estate far more troublesome than lucrative. Finding farming a less congenial pursuit than he expected, he soon gave up his share of the land, and wended his way (travelling often for days on foot) to the eastern shore of Virginia, and there took charge of a country school in a neighborhood where he had stopped to rest, and where the people had been kind to him. His next engagement was with John H. Dennis, Esq., of Maryland, as private tutor in his family, where he remained several years, greatly endearing himself to his patron and to his pupils.

*Of Mr. Tuomey's school days at home in the city of Cork, scarcely anything is known. It is certain, however, that he went to some other school than that of his relative at his grandmother's, for at least a short time. He has been heard to speak of one of his teachers as one who, when the boys were fatigued with study, used to entertain them with his violin.

It was while he was residing in the family of Mr. Dennis that he became acquainted with Miss Sarah E. Handy, a near relative of that gentleman, to whom afterwards, in 1837, he was married.

In the meantime being anxious to pursue his scientific studies, he went to Troy, N. Y., and was graduated from the Rensselaer Institute. After his graduation he was engaged as engineer upon a railroad then in course of construction in North Carolina. The year after his marriage, which occurred while he was thus engaged, the monetary crash which was then prostrating business stopped work upon this railroad, and Mr. Tuomey entered into an engagement to teach mathematics and natural sciences in the school of Miss Mercer, in Loudoun county, Virginia. Here he remained eighteen months, after which, with his wife, he established a seminary in Petersburg, Virginia. While in Petersburg, Mr. Tuomey began to put his scientific acquirements to some practical use. Here he met and entertained on both his visits to America, Sir Charles Lyell; here he made large collections in geology, mineralogy and paleontology: here he entered into correspondence with Agassiz, with James Hall, state geologist of New York, with Prof. Bache, superintendent of the Coast Survey, with Prof. Dana of Yale college, with Dr. Gibbs of Charleston, and also with many foreign scientific men.

It was near Petersburg that he discovered a bed of infusorial earth which was considered a great piece of good fortune. Foremost among the friends Mr. Tuomey made in Petersburg was Edmund Ruffin, so well known in the department of chemistry and practical agriculture. By the kindness of this friend he was recommended to governor Hammond, of South Carolina, who appointed him state geologist of South Carolina in 1844. While thus engaged he became associated with Prof. Holmes, of Charleston, in the publication of a magnificent work on the fossils of South Carolina. He published also two official reports on the geology of that state. In 1847, he was appointed to the professorship of geology, mineralogy and agricultural chemistry in the University of Alabama. During his professorship, Prof. Tuomey began to make examination of the geology of Alabama, the University defraying his expenses; and in 1848 he was appointed state geologist

without salary. In this relation to the State and the University he continued one year, performing much hard labor in the field of developing the State's mineral wealth, and so impressing the Legislature with the importance of the survey that they made an appropriation in 1854 of $10,000 for the geological survey. Prof. Tuomey then resigned his professorship and gave his entire time to the new survey, until the appropriation was exhausted. He then resumed his place in the University with the design of seeing, at his leisure, his reports through the press, and completing the office work of the survey. In this work, before either design was executed, he was prostrated by a disease which, at length, on the 30th of March, 1857, terminated fatally.

Although Prof. Tuomey kept himself perfectly informed with regard to the progress of scientific discoveries all over the world and was a great and judicious reader, he was never so much a student of books as of nature. He was eminently a self taught man, and he possessed the faculty of giving his conclusions promptly and correctly, and of expressing them concisely. In social life, Prof. Tuomey, like all true, pure-minded men, who are learned, was an agreeable person. He was a man of great information, and his memory was stored with instructive facts and amusing anecdotes. These qualities, joined to the manners of a finished gentleman of the old school, and a manly, dignified presence, made him a most agreeable companion. His conversation was to persons less learned than himself interesting and instructive, without any effort or recognition of the fact in his own manner. In speaking he did not overawe his audience by his own profundity, nor strive, as many do, to impress them with the consciousness of how little they knew. It was a peculiar pleasure to him to discover and cultivate in those who possessed it, a talent and disposition to scientific pursuits, yet latent for want of books and encouragement: and there are many persons now living, who for themselves and their better instructed children, will ever have cause to thank him for their first impulses to a study which, though it may scarcely merit to them more than the name entertainment, has yet filled their cabinets with specimens, and stored their minds with much pleasing and important popular knowledge.

As a teacher Prof. Tuomey possessed in a remarkable degree the faculty of interesting the student, and those even who took no particular interest in the subject matter of his lectures, were attracted by his style and found both entertainment and instruction in his discourses. His native Irish wit did much to render his lectures entertaining, especially to those who were not the victims of it, for it must be admitted that he did not always spare the feelings of the student at whose expense he could make a good point. He was particularly unmerciful in his rebukes and exposures of shams and affectations.

The quality which attracted the students in his lectures makes his geological reports very interesting reading. I think no one can read one of these reports without having his interest enlisted from the start. One of the elements which contributes perhaps most to this interest, is the impression conveyed by his writings that the author is speaking out of the fullness of his knowledge.

That he understood his business well is appreciated best by those who are best acquainted with his field of labor. His first report and map of the geology of Alabama were prepared after only two years of examination in the field, and yet the boundaries of the different formations were laid down upon the map with a very close approximation to correctness. No one but a master of the subject could have accomplished so much in such limited time. His reports, after a lapse of forty years are still consulted.

The only surviving member of Prof. Tuomey's family is Mrs. Nora T. Maclean of Chattanooga, Tenn. The other daughter, Minnie, was married after the death of her father, to the Rev. R. D. Nevius, the pastor of Christ Church in Tuscaloosa, now of Tacoma, Washington.

Mrs. Tuomey and her two daughters lived in Tuscaloosa for a number of years after the death of Prof. Tuomey, where they were greatly beloved and respected. Prof. Tuomey's grave is in the New Cemetary at Tuscaloosa, marked by a white marble cross.

Capt. Anthony W. Vogdes, U. S. A. has been kind enough to prepare for this sketch a bibliography of Prof. Tuomey's writings, which is given below.

ANNOTATED LIST OF THE WRITINGS OF PROF. TUOMEY.

Prepared by Capt. ANTHONY W. VOGDES, U. S. A.

1842.

Discovery of a chambered univalve fossil in the Eocene Tertiary of James river, Virginia: by M. Tuomey. Am. Jour. Sci. and Arts, 1st Ser. vol. XLIII, p. 187.

This notice of a Nautilus in the Eocene is without a name for the fossil. The specimen was obtained from a shaft sunk at the base of the escarpment at Evergreen, near City Point from a dark colored tenacious clay.

Discovery of a chambered univalve shell in the Eocene Tertiary of James river, Virginia. Ann. and Mag. Nat. Hist., Ser. 1, vol. X, pp. 156-157.

A reprint from Am. Jour. Sci. and Arts, vol. XLIII.

1843.

Notice of the discovery of a new locality of the "Infusorial stratum," by M. Tuomey. Am. Jour. Sci. and Arts, 1st Series, vol. XLIV, pp. 339-341.

The author states that at Petersburg, Virginia, on Poplar lawn, the western edge of the Eocene is cut through and exposed in a small stream which crosses Walnut street. For about the distance of a quarter of a mile southeast from this point the Eocene is again hid by the Heights. These beds are again cut through by a stream which forms the boundary of the corporation; and on the west side of the valley of this stream the infusorial stratum occurs. The author's section gives about 20 feet of Eocene sand and clays with 30 feet for the infusorial bed.

1844.

Report on the geological and agricultural survey of the State of South Carolina, by M. Tuomey, geological surveyor of the State. Columbia. S. C., printed by A. S. Johnston. 8vo, 62 pp.

The report contains a chapter on the Primary rocks. Also a section on iron ores, gold mines, with a chapter on economical geology.

1846.

Report of M. Tuomey Esq., State geologist, S. C., to the city council of Charleston. "Courier" June 25th.

This report contains a section to illustrate the Charleston basin with an account of the artesian well at Charleston.

The report was also issued separately and distributed by the author without date or reference to the newspaper publication.

1847.

On the cranium of the Zeuglodon from the Upper Eocene of South Carolina, by M. Tuomey. Proc. Acad. Nat. Sci. Phila., vol. III, no. 7.

This paper is noted in the Am. Jour. Sci. and Arts, 2d Ser., vol. IV, p. 149; also copied in full on pp. 283-285 of the same volume. The fossil was discovered in the Eocene beds of Ashley river, about 10 miles from Charleston.

1848.

Report on the geology of South Carolina, by M. Tuomey. Columbia, S. C., printed and published for the State by A. S. Johnston. 4to. 293 pp., with appendix. Catalogue of the fauna of South Carolina, by Lewis R. Gibbes, pp. i-xxiv. Meteorological tables. by Robert Lebby. Copy of Vanuxem's Report from Mill's statistics of South Carolina, pp. xxxi-xxxii. Indigo, analysis of marls and soils, with index, pp. xxxiii-lv, and geological map of the State.

Reviewed by Thomas S. Bouvé, Amer. Jour. Sci. and Arts, 2d Ser., vol. VIII, pp. 61-73. 1849. The first four chapters of this report give an interesting treatise on the science of geology, embracing a general description of the formations of the earth's surface. The eight chapters on the geology of the State contain an account of the unstratified rocks found in South Carolina, exclusively in the upper or northwestern districts: also chapters on the nonfossiliferous series of stratified rocks. Iron ores. The gold formation received the author's particular attention. Chapter IV, relates to the disintegration and denudation of the Primary and metamorphic rocks, Palæozoic rocks, etc. Chapter V, geology of the upper districts. Chapter VI, Upper Secondary or Cretaceous system. Tertiary series. Eocene. Beds of the Charleston basin, etc. Chapter VII, Economical geology.

Letter to Dr. S. G. Morton from M. Tuomey. Proc. Am. Assoc. Advt. Sci., vol. I, pp. 32-33.

Prof. Tuomey states that six species of Cretaceous fossils are found at Wilmington, N. C., and Santee, S. C., commingled with an Eocene molluscan fauna.

The characteristic Cretaceous forms are: *Ammonites placenta* De Kay, *Trigonia thoracica* Morton, *Terebratula harlani* Morton, *Plagiostoma gregale* Morton, *Ostrea panda* Morton. *Gryphæa mutabilis* Morton.

1850.

First Biennial Report on the geology of Alabama by M. Tuomey, geologist of the State: professor of geology in the University of Alabama. Tuscaloosa, printed by M. D. J. Slade, 8vo, 176 pp. Reviewed Am. Jour. Sci. and Arts, 2d Series, vol. x, pp. 299-300.

A geological map was prepared to accompany this report but it was not received from the printer in time for publication with the report. Some few copies were distributed by the author in sending out the report. The report contains chapters on the Primary and metamorphic rocks of Alabama; Silurian or older fossiliferous rocks; Economical relations of the Red Mountain group; Carboniferous system, with economic relations; Cretaceous and Tertiary systems.

1851.

Notice of the geology of the Florida Keys and of the southern coast of Florida, by M. Tuomey. Am. Jour. Sci. and Arts, 2d Series, vol. XI, pp. 390-394.

1852.

Description of some fossil shells from the Tertiary of the southern states. Proc. Acad. Sci., Phila., vol. VI, pp. 192-194.

The fossils described are from Wilmington. The author states that among the characteristic Eocene fossils several equally characteristic Cretaceous forms are found, but he regards the commingling as having occurred while all the forms in question were living.

1854.

Description of some new fossils from the Cretaceous rocks of the southern states. Proc. Acad. Nat. Sci., Phila., vol. VII, pp. 167-172.

1855.

A brief notice of some facts connected with the Duck Town, Tennessee, copper mines, by M. Tuomey. Am. Jour. Sci. and Arts, 2d Series, vol. XIX, pp. 181-182.

1857.

Reports on the survey of the summit level of the James river and Kanawha company, and on a geological examination of the line of canal and contemplated reservoirs. Richmond, printed by John Nowlan; 30 pp., with plan of geological structure of Anthony's creek reservoir.

Prof. Tuomey's report on the geology forms pp. 5-16 with eight sections on the mineral composition and geological structure of the rocks forming the basins to be occupied as reservoirs and of the portion of the line of canal examined.

Pleiocene fossils of South Carolina containing descriptions and figures of the Polyparia Echinodermata and Mollusca by M. Tuomey and F. S. Holmes. Charleston, 4to. Russell and Jones, printers. 152 pp. 30 plates.

Prof. Tuomey intended to publish some twenty plates of the fossils of South Carolina, in his final report of 1848, which was nearly two years in passing through the press, and ommitted from the final report. The disappointment of geologists, occasioned by this ommission, was the common topic of conversation at the meeting of the American Association at Charleston, in May, 1850, and at the solicitation of a number of the members the authors of the Pleiocene fossils of South Carolina published this work at their own risk and cost.

1858.

Second biennial report on the Geology of Alabama, by M. Tuomey, Geologist to the State, etc. Edited from the author's ms. and other papers, by J. W. Mallet. Montgomery, N. B. Cloud, state printer. 8vo., 292 pp.

Geological map and sections. Reviewed Am. Jour. Sci. and Arts, 2d Ser., vol. XXVII, p. 436, 1859.

The geological report contains chapters on North Alabama, Metamorphic rocks of East Alabama, Silurian rocks of Shelby, Benton and DeKalb counties; Economic materials derived from older rocks, Cretaceous and Tertiary rocks of Southeast Alabama, Post-Tertiary deposits of the state, Physical features of Alabama, with an appendix containing reports of the chemical department, Reports on portions of the Cretaceous and Tertiary fossils, List of localities of coal beds, etc.

The volume treats briefly of the geology of the nothern part of the state, giving some facts relating to the Silurian, Devonian and Carboniferous rocks, with descriptions of iron ores and other economical rocks.

OSCILLATIONS OF THE COAST OF CALIFORNIA DURING THE PLIOCENE AND PLEISTOCENE.

By HAROLD W. FAIRBANKS, Berkeley, Cal.

CONTENTS.

INTRODUCTION.

In the following paper it is proposed to trace out, as far as can be done at present, the character and sequence of the crustal movements along the coast of California during the later geological times. The investigation will deal particularly with those which took place during the Pliocene and Pleistocene. Various interpretations of the records left by these movements have been given by different observers, but their results do not harmonize with each other, nor does any one of them appear to express the whole truth.

The study was primarily suggested, partly by the views of professor Le Conte on a former elevation of the coast giving a land connection with the Santa Barbara islands, and partly by the results of the soundings of the United States Coast and Geodetic Survey as announced by professor George Davidson. The recent work upon the Pliocene and Pleistocene movements of the California coast by professor Lawson has resulted in conclusions radically different from those of professor Le Conte and it appears self evident that some one must entertain serious misconceptions.

In developing the subject from observation and study I have been led to the conviction that the later researches have failed to discriminate the different movements in a manner consistent with the actual facts open to observation. It will appear from what follows, that, concerning the important oscillations of the Pleistocene period at least, my conclusions are in accord with those of professor Le Conte.

In discussing the subject I will first give a brief outline of the generally accepted opinions of geologists upon the question in its broader aspects, and then in greater detail, the published results of study of that portion of the Pacific coast contained within the state of California where the most numerous observations have been made. Following this the main portion of the paper will be devoted more especially to a presentation of the leading lines of evidence relating to the epeirogenic as well as the orogenic disturbances of the coast region from the late Tertiary to the present. The special object will be to draw out the fact of an elevation of the coast much greater than the present during the earlier portion of the Pleistocene.

GENERAL MOVEMENTS OF PLIOCENE AND PLEISTOCENE TIME.

The more important events recognized in geology between the closing portion of the Pliocene and the present are believed by many to have been of almost world wide importance. Geikie* says: "The general succession of geological changes in post-Tertiary time appears to have been broadly the same all over the northern hemisphere." Dana's† discussion of this question is substantially as follows: (1) an elevating movement inaugurated near the close of the Pliocene and continuing into the Pletstocene, and terminating in the glacial period, (2) depression during the Champlain period with retreat of the glaciers, followed (3) in the Recent period by another upward movement, and last of all a possible subsidence. He inclines to the opinion that there are evidences of similar Pleistocene movements on the Pacific coast, basing his conclusions upon the terraces reported by geologists from that region, as well as on the presence of submarine valleys described by Davidson. These valleys extend down to depths varying from 2400 to 3000 feet and are considered by Dana as valleys of stream erosion, indicating an elevation of the coast of California of that much probably during the Glacial period. Dana farther quotes Dawson to the effect that an elevation of British Columbia of about 900 feet above the present existed during the Pliocene, that the fiords there occurring were enlarged during the following Glacial period.

*Text Book of Geology, 3d edition, p. 1050.
†Manuel of Geology, 4th edition.

An elevation above the present during the Glacial period is denied for much of the continent by some eminent geologists who believe that the events of that time were not so simple, yet, it seems to be admitted by all that a very considerable uplift was characteristic of the time immediately preceding glaciation, that during glaciation oscillations of level occurred, and at its close a depression, with an elevation in more modern times. Can the Pliocene movements of eastern North America be correlated with those on the Pacific coast occurring in the corresponding geological period? This is at present a doubtful question. The opinion seems to prevail that glaciation in the Sierra Nevadas was more recent than in the east. It is quite possible that with the general movements of higher latitudes there may have been independent orographic movements, or the epeirogenic changes may have partaken of the nature of a wave-like progression. It is certain that on the Pacific coast of the United States, and probably farther north, a subsidence was taking place during much of the time determined as Pliocene by professor Lawson, but whether this subsidence was synchronous with the upward movement of the Atlantic coast is not definitely known. Although it would appear from present knowledge that the two events were contemporaneous, yet there seems to be evidence that from the beginning of the Pleistocene to the present the important epeirogenic movements recognized in eastern North America have had their counterparts on the Pacific coast, although possibly not taking place on both sides of the continent simultaneously.

Earlier Opinions Concerning the Movements of the California Coast.

Professor Le Conte was the first geologist to call attention to the facts bearing upon a former elevation of the coast of California, although Mr. R. E. C. Stearns a number of years earlier, in speaking of the tooth of a fossil elephant which had been presented to the California Academy of Sciences said: "It proved that the island (Santa Rosa) was formerly a portion of the mainland." Professor Le Conte's views* are based

*Bull. Cal. Acad. of Sci., Vol. II, No. 8, p. 515.
American Geologist, Vol. I, p. 76.
Bull. Geol. Soc. of Am., Vol. II, p. 323.
Am. Jour. of Sci., Vol. 34, p. 457, 1887.

partly on the presence of submerged valleys off the coast, and partly on the peculiar flora as well as fossil remains of the Channel islands. During the elevation of the early Pleistocene Le Conte believes that the land stood at a hight of 2000 to 2500 feet above the present level. Then followed a depression the records of which are left in the raised beaches, and last of all an elevation to the position now occupied.

The late W. A. Goodyear* ridiculed the idea of the Santa Barbara islands ever having been connected with the mainland, saying that it was not certain that the elephant tooth presented to the Academy of Sciences ever came from Santa Rosa island. As a matter of fact however the beds of fossil bones occurring there have been described by both Voy and Yates and there cannot be the slightest doubt of their existence. A description of them will be given a little later.

Professor A. C. Lawson has devoted careful study to the Pliocene and Pleistocene movements of the coast of California but his conclusions are not in harmony with the earlier observations. The work of this investigator has extended along nearly the whole coast of the state, and as his results are important and have tended to shape recent opinion I will quote them at considerable length. Professor Lawson presents the following hypothesis† as the result of his studies at Carmelo. "The Pliocene corresponds to the more or less continuous depression of the coast, till the land was at least 800 feet lower than at present: – – –the Quaternary corresponds to the more or less continuous uplift which has affected the coast since the maximum depression was reached. – – –There is no evidence of an elevation of this part of the coast since Miocene times exceeding the present altitude." He does not consider the submarine valleys at Monterey and Carmelo bays as evidence of a former elevation.

In a more recent paper professor Lawson‡ concludes that there has been a recent uplift of 800-1500 feet between the Golden Gate and San Diego. He says farther: "A map of the shore at the beginning of the Pliocene would resemble the one of to-day. A map at the beginning of the Pleistocene would

*Report of the Calif. State Mining Bureau, 1889, p. 169.

†Bull. of the Dpt. of Geol., Univ. of Cal., Vol. I, pp. 57-58.

‡Bull. of the Dpt. of Geol., Univ. of Cal., Vol. I, pp. 157-159.

resemble rather that of the present Alaskan shore." The difficulty of drawing a line of division between the Pliocene and Pleistocene is then discussed and the conclusion reached that it can never be done on paleontological grounds, saying: "The reason for this is that there has been no distinct break in the continuity of marine conditions throughout the epochs, only a gradual transition of conditions. In this gradual transition there was however a reversal of the epeirogenic movement of the coast from a process of depression to a process of uplift. This turning point of the diastrophic pendulum, the intiation of the diastone of the epeirogenic pulsation is believed to correspond well with the beginning of the Pleistocene. -- The two epochs thus delimited have no interval of erosion between them and there will be found no marked break, except locally, in the sequence of marine life."

In another paper professor Lawson* distinguishes Pleistocene terraces to a hight of 1600 feet and possibly more, with the remnants of a Pliocene terrace formed during the deposition of the Wild-cat series. He recognizes three movements: (1) a depression during the Pliocene; (2) an orogenic movement at its close tilting the Wild-cat series; and (3) the general epeirogenic movement of the coast forming the terraces now so distinct. Speaking of the disturbances at the close of the Pliocene affecting portions of the coast he says: "These mountain-making movements were not however adequate to efface the peneplain (Pliocene), and the general altitude of the coast was not apparently affected." We have then at this time according to professor Lawson, the curious anomaly of of mountain-making movements not affecting the level of the coast.

The same investigator† has described a complex series of events which he supposes took place upon the peninsula of San Francisco during the Pleistocene. The region is believed to have sunken through the Pliocene permitting the deposition of the Merced series which is about one mile thick. "At the close of these orogenic movements (deformation of the Merced series) the altitude of the land was much lower relatively to the sea-level than at present. A general depression of the

*Bull. of the Dpt. of Geol., Univ. of Cal., Vol. I, p. 270.

†XVth Annual report of the U. S. Geol. Sur., p. 468.

land seems to have been concomitant with the more acute local disturbances or to have immediately followed them for we find marine terrace formations strewn over the region at an elevation of over 700 feet with a corresponding base-level plateau, and remnants of a still older plateau, also the result of baseleveling, at about 1100 to 1200 feet above sea-level." He goes on to say that from this general depression, excepting the last local sinking about the Golden Gate, elevation by stages has taken place from that time to the present.

The sequence of disturbances given on page 469 of the same report it is difficult to appreciate and is certainly open to question. They are as follows: formation of the San Bruno fault and the uplift of that range and the portion of the San Francisco peninsula lying to the north, resulting in the complete erosion of the Merced beds from the raised block; sinking of the San Bruno fault block; emergence of the San Bruno and Montara fault blocks together; development of terraces with the final emergence. The subsidence posited by professor Lawson as taking place at the time of the post-Pliocene disturbance or immediately following it is a most unique occurrence if true, but the phenomena properly interpreted are opposed to this view. A careful perusal of the report brings out the fact that the term "baselevel plateau" is used for a plain produced by wave action, and apparently does not mean anything more than a large wave-cut terrace. In this as in other papers he considers that in every case where the Pleistocene is found unconformable upon the Pliocene the truncation of the lower beds is always due to wave truncation. It does not appear possible that with a rising land and the accompanying terracing deposits several hundred feet in thickness could very often be formed upon the wave-cut floor.

In an earlier paper professor Lawson* expresses a different view from that quoted concerning Montara mountain, namely, that following the post-Pliocene disturbances it had undergone a period of subaerial erosion similar to that posited for the San Bruno mountains. The uplift however is assumed to have been merely local. The statement is as follows: "In the consideration of the diastrophism which has affected the San Francisco peninsula we have then, two displacements to deal

*Bull. of the Dpt. of Geol., Univ. of Cal., Vol. I, p. 149.

with, the orogenic or local, and the epeirogenic or general uplift. Is it possible to discriminate the two effects? Certain striking facts suggest an answer to this question in the affirmative. The orogenic uplift preceded the epeirogenic, and there was an interval between the movements in which a great denudation was affected." It will be evident from these quotations that it is exceedingly difficult to get at what professor Lawson's ideas really are on this question. His general meaning seems to be, aside from the discrepancies, that the post-Pliocene movements were purely of the nature of upthrusts of local fault blocks portions of which remained at or below the original level, and that the geography of the coast was not affected at all. The epeirogenic uplift referred to is that of the last uplift giving rise to the terraces. I cannot see what there is about the phenomena of these recent movements of the coast of California which makes it necessary to assume such peculiar mountain making disturbances, so different from the usual character of such events.

The views of professor Lawson in his different papers, although showing numerous contradictions, the earlier ones remaining unmodified in the later, may be generalized as follows. For the coast as a whole no marked disturbance appears to separate the Pliocene from the Pleistocene, a depression with transgression of the sea during the former, and a gradual re-elevation through the latter. Marked disturbances are recognized as having taken place locally, but without affecting any general elevation of the coast; while on the San Francisco peninsula a depression is recognized at the time of the disturbance or immediately following it. The San Bruno fault block is excepted, it having undergone a period of erosion before the deposition of the terrace formations. The history which professor Lawson thus recognizes as having been characteristic of San Bruno mountains I believe is characteristic of the whole coast.

Mr. George Ashley* clearly distinguished a period of land erosion between the formation of the Merced sesies and the Pleistocene terraces as the following quotation will show. "The arguments from the structural side are, that while, as shown by the fauna, this formation (Upper Merced beds) is

*Proc. Cal. Acad. Sci., Ser. 2, Vol. V, p. 334.

possibly later than the Pliocene, it is found to be overlaid by horizontal or nearly horizontal strata containing Elephas bones with evidences of a land period between. Since these beds were laid down, therefore, there has been a movement which has tilted them at an angle of 5-40 degrees followed by their being exposed to subaerial erosion, and later by being submerged and covered by deposits at one place over 200 feet thick, and then the whole subjected to a more or less general elevation to its present level. On page 352 of the same paper Mr. Ashley gives additional proof of the above statement.

Demarkation between the Pliocene and Pleistocene.

General Discussion. The Pliocene has been considered to have been closed in eastern North America by a marked elevation preceding glaciation. Lawson has already been quoted as to the condition of the California coast at this time. He has maintained that the coast was sinking through the Pliocene until 800-1500 feet below the present level. When this point had been reached a reversal took place, being preceded by local disturbances, gradually uplifting (epeirogenic movement) the coast to its present level. He considers the dividing line between the Pliocene and Pleistocene the point of greatest depression. Although I would explain differently the movements at the close of the Pliocene, considering them epeirogenic as well as orogenic, I think we must agree with professor Lawson that the point of change or disturbance forms a natural division between the two periods. This point is not an arbitrary one, not merely the reversal of an epeirogenic movement, as Lawson has said, but is marked by an important non-conformity. His statements have led Lindgren into a misconception of the actual condition of affairs in the Coast Ranges. Lindgren* says in a recent article: "It seems that in the maps of the valley border of the Sierra Nevada, the arbitrary line between the Neocene and the Pleistocene has been drawn considerably lower than the similar arbitrary line established by professor Lawson at the top of the Merced series. In other words the Pleistocene as defined in the gold belt maps occupies a considerably longer time than the Pleistocene on the coast as defined by professor Lawson. The Mer-

*Journal of Geology, Vol. IV, p. 905.

ced series is probably contemporaneous with the early Pleistocene of the valley border." It is evident that as yet we scarcely have information sufficient to permit a correlation of the movements in the Coast Ranges with those in the Sierra Nevada with any great degree of certainty. The recognized difficulty in delimiting the Miocene and Pliocene in the Sierras would perhaps be lessened if an attempt were made to take the clearly marked divisions in the Coast Ranges, due to more intense disturbances and changes of level, and see if a paralel could not be found for them in the Sierras, rather than vice versa. It is possible that the uppermost portions of the beds which have been termed Pliocene in the Coast Ranges could with equal propriety be included in the Pleistocene, which Lindgren as well as Ashley has suggested, yet the important stratigraphic break with the overlying Pleistocene makes a natural boundary which I do not think should be overlooked. The middle and lower portions of the Merced beds and Wild-cat series must be placed in the Pliocene if molluscan fauna are of any value in correlation. It seems, therefore, on stratigraphic grounds at least, that the limit of the Pliocene as determined by professor Lawson should be maintained.

Prof. Lawson* would correlate the Pleistocene elevation of the coast with the uplift of the Sierra Nevadas which followed the deposition of the auriferous gravels. It appears to me that these events have no relation to each other. The uplift of the Sierra Nevadas commenced before the close of the Pliocene as determined on the coast, at which time according to the researches of professor Lawson, the Coast Ranges were submerged. Lindgren says that the shore lines of the Sierras retreated westward during the Pliocene and if he correlates that time in the Sierras with any portion of the Pliocene on the coast. as he certainly must, there would appear to have been an upward movement of the Sierras with a downward one of the coast region. It is known definitely that in the earlier portion of the Pleistocene, as delimited on the coast, the Santa Barbara islands were connected with the mainland. The early Pleistocene of the coast would seem to correspond to the middle Pleistocene in the Sierras as given by Lindgren, and

*Bull. of the Dpt. of Geol. Vol. I, p. 158.

hence if glaciation was due to greater elevation, a contemporaneous upward movement was experienced by both at this time. The attempt at correlation may at the present be useless as it is exceedingly difficult to prove that even the epeirogenic movements affected the mountain axes alike. I think nevertheless that the best results are to be obtained by first clearly determining the limits of the Miocene, Pliocene and Pleistocene in the Coast Ranges, and taking the results as standards in the attempt to harmonize the nomenclature over the state.

Detailed Evidence from the Coast Ranges. It is rather difficult to determine the relation existing between the Pliocene and Pleistocene along the southern coast of San Diego county, although there are indications that the former has been somewhat disturbed and that the latter rests unconformably upon it. The highest terrace noticed by Lawson* in this region has an elevation of 800 feet. South of Poway valley however there are terraces of bedded gravel having an elevation of at least 1500 feet.

Between Oceanside and San Juan there is a stretch of mountainous country presenting some interesting features. Here occur very extensive beds of late Tertiary age, probably Pliocene, much disturbed and faulted and marked with Pleistocene terraces. The terrace deposits rest unconformably upon the slightly consolidated sands and conglomerates of this region. There is a distinctly marked baseleveled plateau of 2500 feet elevation forming a shoulder of the Santa Margarits mountains, but it may belong to a different epoch than the terraces. The San Onofre mountains have been raised by a fault which judging from the topography, cannot antedate the post-Pliocene disturbance.

Professor Lawson speaks of the Pliocene strata at San Pedro hill as being slightly deformed and truncated by wave action, and that on this surface the Pleistocene has been deposited. He says† further: "It follows that while there is a very profound physical break between the Miocene and Pliocene, the marine Pliocene and Pleistocene formations are very intimately associated with no epoch of subaerial denudation between them."

*Bull. of the Dpt. of Geol., Univ. of Cal., Vol. I, p. 120.

†Bull. Dpt. of Geol., Univ. of Cal., Vol. I. p. 128.

As in the case of the Pliocene of the northern coast an interpretation in favor of a period of subaerial erosion seems more reasonable. The very fact that the Pliocene has been disturbed and tilted is evidence which on its face would call for such a period of erosion.

Whitney* describes the Pliocene strata at Santa Barbara, which unconformably overlie the Miocene, as follows: "These strata themselves unconformable with the slates below are again overlaid unconformably by the recent or modern alluvial deposits."

Yates has described the Pleistocene strata of Santa Rosa island as overlying unconformably the slightly tilted Pliocene. This occurrence will be described at length in another place.

Both Whitney† and Lawson‡ mention the fact that the supposed Pliocene beds on the upper San Benito river have been faulted and tilted. The latter author§ also describes a slight tilting and faulting of the Pliocene beds at Carmelo. The description given is remarkably suggestive of the post-Pliocene disturbance and elevation which I have noted at other points

He speaks of the "older" and "newer" terrace deposits, the former being slightly tilted and faulted, and formed during the Pliocene submergence, the latter deposited during the re-elevation in the following Pleistocene. An unconformity is noted between the two in the sea cliffs and in the valley of the San Jose creek where a sheet of lava occurs separating two portions, the upper of which is less consolidated and without distinct bedding. The recent terraces are also described as having been cut in the older terrace deposits which are faulted into the carmeloite lavas. It seems to me clear from these descriptions that there is good evidence of an extensive disturbance and uplift accompanied with lava flows marking the line of division between the Pliocene and the more recent deposits. This disturbance was neither "local" nor is it possible to believe that the unconformity was marked by a period of wave erosion alone. The Wild-cat series (Pliocene) on the coast of northern California is described by professor Lawson as hav-

*General Geology of California, Vol. I, p. 134.
†General Geology of California, Vol. I, pp. 53-54.
‡Bull. Dpt. of Geol., Univ. of Calif., Vol. I, p. 153.
§Bull. Dpt. of Geol., Univ. of Calif., Vol. I, p. 56.

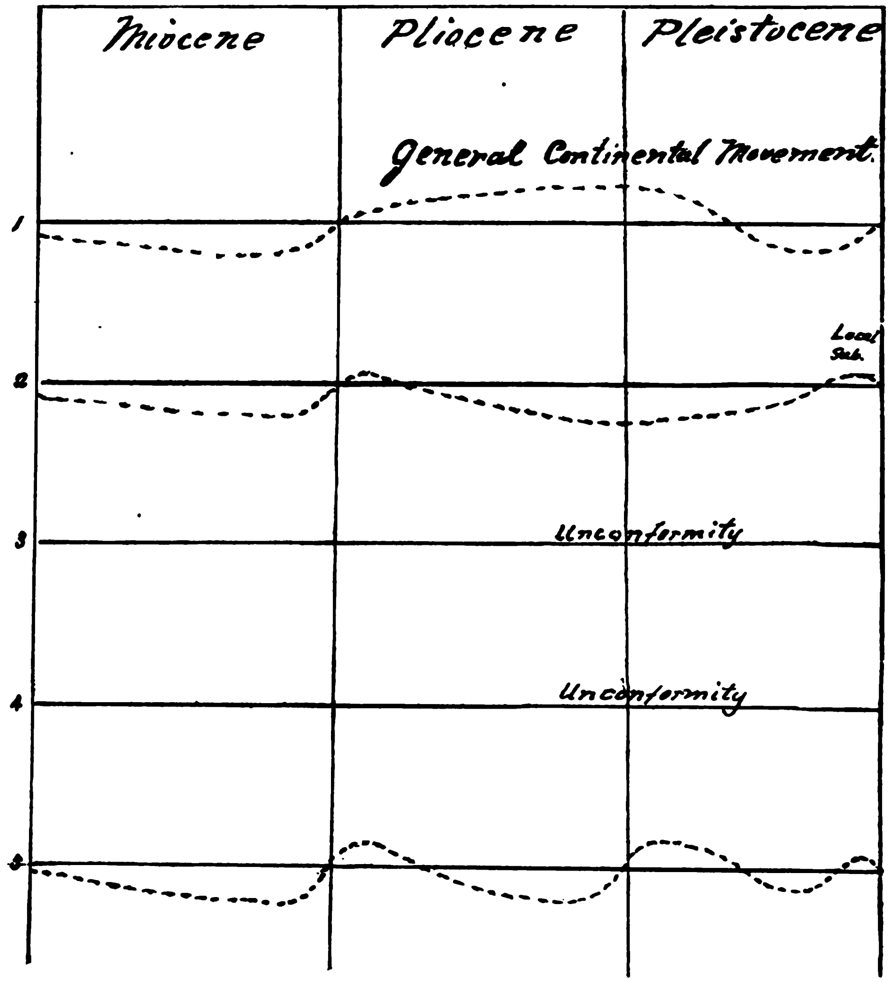
ing been affected by an orogenic disturbance which threw the Pliocene peneplain into "orographic blocks and anticlinal arches," but without any accompanying uplift. The evidence for no uplift will have to be made much stronger than it appears from the description given, before it can be used to offset the result of many lines of research all of which point to a very considerable uplift following the post-Pliocene disturbance the whole length of California. It is difficult to understand also how the Pliocene peneplain could have remained in a distinguishable condition after the beds of that age in the same region had been so generally deformed.

According to professor Lawson* the Pliocene is extensively developed in the hills back of Berkeley, east of San Francisco bay. The beds have been quite sharply folded and are briefly referred to in part as follows.† "The Pliocene rocks were all affected by sharp orogenic deformation prior to the general uplift of the coast." He mentions an "uplifted coastal peneplain" in these hills whose average elevation is about 1500 feet, but whether due to wave action or subaerial erosion is not stated. It is impossible to believe that in the Berkeley hills the post-Pliocene disturbance which so steeply tilted and faulted the Pliocene beds found there should not have elevated them above the sea and subjected them to a period of subaerial erosion before the depression took place in the recovery from which the terraces were formed.

Turner‡ has shown that mount Diablo was elevated at the close of the Pliocene and that the Pleistocene deposits lie unconformably upon the rocks of the former period.

Enough geological work has been done in the Coast Ranges to show that the post-Pliocene disturbances were not local but affected in varying degree the whole coast; that with this mountain-making process there was also associated a general uplift. The fact of a disturbance and elevation at the close of the Miocene is not questioned by any geologist and there is no valid reason for doubting that the similar phenomena marking the close of the Pliocene were due to similar causes. I cannot see anything in the nature of the phenomena present-

*Bull. Dpt. of Geol., Univ. of Calif., Vol. II, p. 94.
†Bull. Dpt. of Geol., Univ. of Calif., Vol. I, p. 268.
‡Bull. Geo., Soc. of Am., Vol. II, p. 402.



Diagrammatic representation of the views of different geologists concerning the movement of the California coast.
1. Le Conte; 2. Lawson; 3. Turner; 4. Ashley; 5. Fairbanks.

ed to show that at the time of this latter disturbance these beds were folded beneath the sea, and that the erosion preceding the formation of the terraces was due solely to wave action, for wave action must have been carried on at the level of the sea, and after truncation, unless there was subsidence, there would have been no opportunity for the terrace formations, sometimes 100 to 300 feet thick, to have been left unmodified and unconformable upon the Pliocene, which as a matter of fact we find to be the case almost everywhere.

Post-Miocene Uplift.

There seems to be no question in the minds of geologists concerning the post-Miocene disturbance and uplift. By many it has been believed that the Coast Ranges originated at this time, but this, as I have shown in other papers, is clearly an erroneous conception, as the records of several stratigraphic breaks are visible in the older rocks of this region. It is very probable that the post-Jurassic disturbance elevated the coast so that the present islands were connected with the mainland and much of the submarine plateau exposed. As yet we know in only a general way the effects of the post-Miocene disturbance, but I believe that there are good reasons for assuming that the uplift was very marked and that the shore line was forced out some distance beyond the present one, probably taking in the submarine plateau. The Miocene is everywhere overlaid unconformably by the later formations. The valleys originating with the post-Miocene uplift, due partly to structural conditions, and partly to erosion, were more or less filled with sediments during the Pliocene submergence. With the early Pleistocene elevation they were again cut out, and filled during the following depression with the terrace deposits. As a result of this sequence it becomes difficult always to correctly discriminate and refer any particular phenomena of erosion to its true source. If we were in the possession of more records of deep borings in the mouths of the large valleys opening out upon the coast the question might more easily be settled. It is very evident however from the character of many of the larger valleys where the Pliocene reposes unconformably upon the Miocene that this relation extends below the present level of the sea. If this is the case these Miocene valleys are not simply of structural origin, and subsequently

filled with Pliocene and more recent deposits, but were excavated during the period of high altitude following the Miocene. The submarine valleys were then either originated or enlarged. There is good reason then for believing in several periods of high elevation in pre-Pleistocene times, a fact which makes it more difficult with present knowledge to distinguish the effects of the early Pleistocene elevation which it is the most particular object of this paper to demonstrate.

EVIDENCES OF A POST-PLIOCENE DISTURBANCE AND UPLIFT.

The Santa Barbara Islands. The evidence furnished by the vertebrate remains as well as by the flora of the Santa Barbara islands has been considered by professor Le Conte as abundant proof of an early Pleistocene elevation of the coast of California. The opposing opinion has strangely overlooked these facts in assuming a submergence at this time. Our knowledge of these islands is as yet very incomplete as far as the geology is concerned, but two observers have described the occurrence of the Elephas bones on the north side of Santa Rosa island. Dr. L. G. Yates* refers to the beds as follows. "On the north side of the island about 10 miles from the wharf, near the mouth of Soledad canon, we found an excellent exposure of strata consisting of about 90 feet of post-Pliocene deposits containing fossil bones of vertebrates, and at one place, fossil Physas (P. d'orbingniana) at a depth of some 75 feet below the surface.

This deposit is horizontal and overlies strata of older rocks probably Pliocene, which dip 13° N. E. and contain *Pecten*, *Turbinella caestrum*, and *Hinnites gigeontea* in abundance and in an excellent state of preservation. There is no indication of drift on Santa Rosa island, hence we cannot account for the presence of the fossil elephant on the theory of its having been brought by floating ice as advanced by some writers." He goes on to say that the chain of islands was formerly connected with the land to the east and that the Santa Barbara channel was a sound opening out to the west.

In an unpublished manuscript in the possession of the State Mining Bureau the late Mr. C. D. Voy describes the geology of Santa Rosa island in more detail. The older rocks of the is-

*AM. GEOL., vol. v, p. 51.

land appear to consist according to Mr. Voy of the Miocene and contain numerous characteristic fossils of that period. Above this is the great body of volcanic material, flow tuffs, etc. Mr. Voy's description is not clear in regard to the relative ages of the volcanic and Pliocene, but it would seem that the lavas, in part, at least, overlaid the Pliocene. The latter formation is widely distributed over the island and very fossiliferous. At various points along the bluffs on the northwest side the Pleistocene deposits appear 20 to 50 feet above the water and consist of clay and gravel. The Pleistocene also covers much of the island, overlying the volcanic. The bluffs are 100 to 200 feet high, and in the clay at various points, as well as in the little ravines on the surface, are numerous bones of the mammoth (E. primegenius), but all in an exceedingly poor state of preservation. Mr. Voy thinks there are two species represented. They occur 20 feet above the Pliocene and 100 feet below the surface. The specimens brought away are very fragmentary, but are to be seen in the Museum of the California State Mining Bureau. The first specimen from this locality, a tooth, was obtained by a Mr. Blunt in 1871.

Dr. Yates* gives a long list of Pliocene fossils from San Nicholas island. He also mentions the occurrence of pebbles of quartzite, porphyry and talcose rocks. Similar ones are also found on Santa Rosa island. The pebbles in the recent formations on these islands indicate shallow water conditions. The Miocene sandstones and shallow water fauna also point to a land area in this region during that period. The fact that the Pliocene rests unconformably upon the older rocks shows the existence there of an interval of subaerial erosion similar to that following the Miocene upon the mainland. The islands were undoubtedly largely submerged during the Pliocene. Then an elevation took place with a tilting of the Pliocene and resulting erosion. The vertebrate remains occurring near the base of the Pleistocene point to the fact that the subsidence took place following the death of the animals. There seems to be every reason for correlating this depression with that recognized in the terrace deposits of the mainland.

The beds of mammoth bones is such conclusive proof of a

*IXth Report of the Cal. State Min. Bureau, p. 58.

former land connection that no question can be raised in regard to it. It might be supposed, however, that the islands were formed simply by a sinking of the region now occupied by the Santa Barbara channel. This view is not supported by the conditions existing since the early Pleistocene; no differential movements of such magnitude are known to have occurred. The recent downward movement has been general, affecting both mainland and islands. There are numerous facts, however, which point to the elevation of the coast as a whole, at the time when the mammoth flourished, which will be taken up in their proper place.

The deepest point on the submarine ridge connecting the Santa Barbara islands with the mainland is 125 fathoms or about 750 feet. This connecting ridge extends eastward toward Point Hueneme, near the mouth of the Santa Clara river. In all probability the post-Pliocene elevation was more than 1,000 feet. An elevation of 1,300 feet would connect the western-most of the islands with point Conception. The centre of the channel forms a depressed basin with a depth of about 2,100 feet.

The Submarine Plateau. The work of professor George Davidson* has shown that the coast of California, as well as of Oregon and Lower California, is bordered by a submarine bench or plateau of varying width. Along the coast of northern California it is quite narrow, being not much over 10 miles across. From Point Arena southward it begins to widen, sweeping just outside of the Farralones islands, and then narrowing again as the bay of Monterey is approached. Opposite the Golden Gate it has a width of about 32 miles. Off the coast of California the plateau of the Pacific has a depth which varies from 2,000 to 2,400 fathoms. The marginal plateau generally slopes very gradually out to the region of the 100 fathom curve, when it takes on the much steeper descent to deeper portions of the plateau or abyssal depths. Opposite the high and rugged Santa Lucia mountains the 100 fathom curve runs four to six miles from the shore, and from that the descent is rapid until a distance out of 57 miles, when it reaches a depth of 2,000 fathoms. Far-

*Hydrographic charts of the U. S. Coast and Geodetic Survey. Submerged Valleys of the Coast of California, Proc. Cal. Acad. of Sciences, 3rd series, vol. I.

ther south, except off Pt. Conception, where it is only 35 miles across, the plateau widens greatly, sweeping outside of the Coast islands which lie off southern California, where a width of 150 miles is shown. The islands and shoals are dotted over this submerged region in a manner approximately corresponding to the direction of the adjacent mountains on the mainland. The slope outside the 100 fathom line along the southern coast is accentuated, but not so markedly so as farther north. The surface of the broad portion of the plateau is far from being uniform. Some of the islands rise over 2,000 feet above sea level, while the depths of the sea at their bases often reaches 600 fathoms. Southwest of San Diego about 35 miles there is the greatest depression in the plateau. Along the coast of Lower California the plateau narrows. How shallow portions of the plateau are, is shown by the fact that the 30 fathom line would include the larger of the Farralones islands lying 20 miles off the shore opposite the Golden Gate, while the 25 fathom line takes in the Coronados islands 12 miles off shore opposite San Diego.

The charts show a large number of submarine valleys opening from landward down across this plateau reaching a depth of from 100 to 500 or more fathoms. Where the plateau is narrow, as on the northern coast, they cut a trench completely across it. Where the width is greater off the coast of southern California the valleys open from the shore down merely to the deeper portions of the plateau itself. In several instances the valleys come very close to the shore, as at La Jolla, Newport, Hueneme, Monterey, and on the coast of Humboldt county. A most remarkable fact about these valleys is that they are generally nearly or quite at right angles to the shore line, and consequently to the broad structural features of the country. Professor Lawson's view that they are structural depressions seems utterly untenable in the light of this as well as other facts. An interesting feature of the plateau, especially that portion above the 100 fathom line is its very even surface. Across this surface the deep transverse valleys have been trenched. The submarine contours follow that of the shore line to varying depths, corresponding very closely sometimes down to 300 fathoms. Not only does the submarine surface present a smoothness in most marked con-

trast to much of the land adjoining, but what is more surprising, the valleys beneath the water do not in some cases seem to bear any relation to the topography of the land lying opposite. The most of the depressions do however appear to be related to corresponding depressions in the land toward which they head.

Now the question arises as to the manner in which this bench has been formed. Is it due to truncation or sedimentation or to structure? In its broad features I believe that we must hold it to be of structural origin, but nevertheless modified by both the other agencies. In general the width of the plateau bears very little relation to the important drainage features of the land, and even where at first sight there would appear to be a correspondence supporting the view that the plateau has been built up by sedimentation a closer examination shows that such is probably not the case. The plateau widens opposite the Golden Gate where the floods from the Great Valley sweep out into the ocean, but even here the outer edge of the bench is bordered by the Farralones islands which are formed of the ancient granites of the Coast Ranges. If the even surface is due partly to truncation and partly to sedimentation without any greater elevation than the present ever having been experienced it is most difficult to account for the transverse valleys. Faulting cannot possibly explain them. It seems to me that as first suggested by professor Le Conte, and in harmony with the other lines of evidence, the position and character of these valleys point to a former elevation of from 2000 to 3000 feet. It is true that the submarine valleys may have been originally cut out at the post-Miocene elevation, or even earlier, but the fact that they have not been filled and extend up so close to the shore in places points most conclusively to a comparatively recent elevation of the coast. How faulting without subaerial erosion could have produced the contours of the valleys as given by Davidson it is impossible to conceive, and when to this is added the fact that they do not conform as a general thing to the important structural features of the Coast Ranges we are compelled to seek a different explanation. In cases where a submarine valley comes up to the shore directly opposite the mouth of a land valley where the Pleistocene is at least hun-

dreds of feet deep it seems that the explanation can be sought only in a comparatively recent elevation of the coast. It must be borne in mind however that opposite the mouths of some of the larger streams no submarine valleys have yet been found. This fact might be accounted for by unusual local conditions during the epeirogenic movements. The soundings in places are also far from complete. A study of the nature of the bottom does not help us much. According to the charts sand extends down 40 to 75 fathoms. Rocky bottom is rarely found.

Beginning at the south I will mention briefly the important submarine valleys which the contour lines upon the charts show. A number of these valleys occur along the coast of Lower California, but will not be taken up. The first deep valley running in close to the shore is found at La Jolla, about 15 miles north of San Diego. It heads in a little bay just north of the town and opens out northwestward. The bay is bordered on the south by Chico sandstone, and on the north by the Tejon, while at its head there is a sandy beach one mile in length. Back of this lies a small valley extending into the Soledad hill, two miles distant. The mouth of the valley at least has been cut out on the northern limb of an anticlinal arch. No bedrock is exposed along the sandy stretch nor in the valley which gradually narrows toward the hills. The contour lines of the submerged valley sweep into the bay directly opposite the land valley, the 100 fathom curve being less than one mile out. The submarine valley is deep and narrow, extending down below the 300 fathom contour six to seven miles from shore. There must assuredly be some connection between this eroded land valley and what is apparently its prolongation beneath the sea. The evidence is conclusive that where the strip of beach occurs the land valley has at some time been eroded deeper than it is now and subsequently filled in. There is every reason to believe that the two valleys are really one and that the submarine prolongation was excavated by the same means as that on the land. The period of excavation is not indicated by anything observed here.

Following the coast northward no important trench appears until Newport is reached. Here opposite the mouth of the Santa Ana river is a narrow valley, not however extending below the 100 fathom contour. The country is low and marshy

along this part of the coast and it is impossible to believe that any structural conditions affecting the soft Pliocene and Pleistocene deposits could have formed a valley of this kind, and there can be no other explanation but that of a comparatively recent subsidence.

North of San Pedro hill near Redondo there is a long, deep and narrow valley extending up very near to the shore. Another valley but not so narrow occurs off Santa Monica. The Redondo valley extends easterly toward the very northern portion of San Pedro hill which according to Lawson consists at the base of Miocene shale dipping westward at an angle not to exceed 30 degrees. The northern and eastern sides of the hill consist of more recent formations. As the submarine valley extends east and west it is consequently not at all likely that it is of structural origin. Lying to the east back of both valleys is the broad Los Angeles plain of Pliocene and Pleistocene strata. It appears to extend beneath the sea forming a broad even slope down to the 100 fathom line.

The next broad land valley to the north is that of the Santa Clara river, which flows across Ventura county, with a general east and west course though bending toward the south near its mouth. Opposite nearly the middle of the broad alluvial bottom of this valley, though some miles south of the present mouth of the river, is another submarine valley reaching a depth of 300 fathoms and extending up very closely to the shore. Its direction is the same as that of the land valley on which it opens. As is the case with most of the submarine valleys this one is narrow and deep, and the question arises why is this so when the corresponding land valleys are often as in the present instance miles in width. If due to subaerial erosion their upper portions at least must have been cut out of the Pliocene deposits which filled the post-Miocene erosion valleys. Their narrow deep form would indicate that the post-Pliocene elevation was of a comparatively brief duration.

About six miles to the south of the valley described, and nearly opposite the present mouth of the Arroyo Las Posas, is another submarine valley of about the same size as the last and extending more nearly north and south. It reaches to a little greater depth than the last, but also extends up close to the shore, terminating near the west end of the lagoon at

the mouth of the arroyo. Both of these valleys are so situated with reference to the alluvial bottom that a structural origin does not appear possible.

The conditions at Santa Catalina island bear out exceedingly well the view of a former elevation. The submarine contours around the island have a curve very similar to that of the shore, indicating an extension of the main features of the topography to a depth of over 300 fathoms. The island is very steep, and rugged and the absence of terraces is no proof, as Lawson seems to think it is, that the island was never submerged. Mr. W. S. T. Smith* has recently shown that the land was submerged during the Miocene as much as 1400 feet below the present level and that in the recovery from the depression, at least one terrace was formed. He also expresses the opinion that in pre-Miocene times the island was elevated 2000 to 3000 feet above the present level. A recent subsidence is shown to have taken place amounting to about 350 feet. Thus many facts go to show that the history of the island in a general way corresponds to that of the mainland. The same thing is probably true of the Santa Barbara islands. The submarine contours about these islands from 100 to 300 fathoms down accord very well with the present shore contours.

At Carmelo bay, some distance northward, occur the next known submarine valleys extending close in to the shore. By Lawson they have been ascribed to faulting. He says:† "At Carmelo Bay there is no evidence of an elevation of this part of the coast since Miocene times exceeding the present altitude." There are two branches of the submarine valley occupying the bay, the larger and deeper of which lies to the south opposite the mouth of the San Jose creek. The valley of this stream extended seaward would accord exactly with the submarine depression.

The great valley extending east and west through the bay of Monterey reaches from near the mouth of the Salinas river down to an unknown depth, probably across the plateau to the abyssal depths of the ocean. This valley is also considered of structural origin by Lawson as the Miocene strata on

*Proc. Cal. Acad. of Sci. III Series, Vol., p. 69.
†Bull. Dpt. of Geol., Univ. of Calif., vol. I, p. 58.

both sides of the bay dip under it. The form of the depression does not however indicate a simple syncline, for the descent is gradual both on the north and south to the 100 fathom line below which it changes quite abruptly becoming very steep. The submarine valley proper on a section between Santa Cruz and Monterey is not over 4 miles wide, descending to 400 fathoms, while the main bay is 24 miles across. According to Lawson the sedimentary rocks dip westward at Pajaro, and taking in connection with this, the submerged northwest prolongation of Point Pinos, an east and west structural depression is rendered improbable. Granting that the broad features of Monterey bay are due to folded Miocene strata, that is are structural, the portion of the submarine trench extending up close to the shore near the mouth of the Salinas river must lie in strata more recent than the Miocene. In all probability the rocks of this age are much more than 1000 feet below the surface, which about the mouth of the river consists of Pleistocene and Pliocene strata. The Salinas well some distance back from the mouth of the river did not apparently reach through the Pleistocene at a depth of 1300 feet.

The recent subsidence at the Golden Gate forming a new outlet for the Great Valley accords very well with the absence of any marine valley at that point and supports the view of professor Le Conte that the outlet was at one time into the bay of Monterey.

Several submarine valleys* have been detected off the coast of northern California. These lie near together south of cape Mendocino and are quite remarkable in several ways. The distance between them is 8-10 miles and they cut across the submarine plateau at depths varying from 400 to 520 fathoms. Only one of them lies opposite a river's mouth, the coast generally rising very steeply to hights of 4000 feet a little over two miles from shore. The submarine valleys extend in remarkably close to the shore, one having a depth of 25 fathoms less than one third of a mile out. Another reaches to a point where the water is not more than 15 fathoms deep. They all lie very nearly perpendicularly to the coast line. The submerged plateau between them has a gentle and even slope down to the 100 fathom contour at a distance of 8 to 10 miles

*Proc. Cal. Acad. of Sci., 1886-1887.

from the land, where it begins to descend rapidly. While it does not seem that these valleys can be accounted for through structural conditions, the hypothesis of stream erosion does not at first sight appear well supported. However the fact that the mountains rise so ruggedly behind them to such hights, would, with increased elevation, result in the cutting of considerable canons across the plateau even if no large rivers debouched here. Their narrow deep character like those farther south would indicate a comparatively brief period of erosion.

Evidence from the Present River Valleys. Our knowledge of the submerged valleys is not complete enough at present so that we can decide certainly concerning earlier elevations from this source alone. But there is another line of research which t ken together with what has been presented leads irresistibly to the conclusion of the much greater elevation of the Pacific coast at several periods in the course of its history. This other question deals with the character of the present stream valleys where they debouche upon the coast. Nearly all the streams of the California coast are bordered by broad alluvial bottoms where they enter the ocean and for many miles back. They are not only at their baselevel of erosion but are actually flowing upon beds of unconsolidated sands and gravels of unknown depth. The bottom lands at the mouths of some of the rivers are 8 to 15 miles wide with no solid rock apparent anywhere except in the hills flanking them. What is the explanation of this fact? One of two solutions is possible, either they represent structural depressions which have been filled up to the present baselevel, or ancient valleys eroded during some former elevation and subsequently depressed and filled with sediments.

The main valleys of the Coast ranges generally follow the structural features and if they all did so the question could not be greatly elucidated by a study of them. There are however many exceptions to the rule, especially among the lesser valleys, some of the more important of which will be discussed. Perhaps the use of the term structural depression ought to be more fully explained. By it I mean a synclinal trough originated by folding, lying either below the sea or baselevel, and which has subsequently been filled by sedimentation.

Faulting as well as folding may determine the original courses of the main streams but be followed by extensive erosion if elevated above the ocean sufficiently. In the latter cases I would not consider the valley, for the purposes of this discussion at least, as of structural origin.

I will now enter upon a description of some of these valleys beginning at the south, and attempt to discriminate the phenomena of the post-Pliocene elevation from the others and also the indications of a very recent subsidence. The streams which flow westward to the ocean across San Diego county are baseleveled in their lower portions having cut sharply defined valleys across the mesa. Near the ocean they have broad alluvial bottoms the depth of which is not known. It must however in many cases be several hundred feet judging from the abrupt nature of the valley walls. The streams entering the ocean from the San Diego river southward to the Mexican line have not as far as known cut through the Pliocene to expose any older sedimentary rocks. The lower valley of the Tia Juana river is particularly broad and here the alluvium or Pleistocene is apparently very deep. The thickness of this deposit in the valley bottom is something less than an earlier Pleistocene elevation. How much less it is impossible to say for that elevation would have thrown the coast line nearly 12 miles to the west. There has taken place however a recent subsidence of moderate amount which complicates matters. In discussing the movements of the coast of southern California Lawson failed to recognize the fact of this subsidence, which is very marked at the mouths of many of the smaller streams. From Del Mar northward nearly all the valleys are flooded, the tide waters entering some of them a distance of nearly two miles, while the depressions of their mouths are often below level of low tide. The sea cliffs are also actively being eaten away. The streams about the bay of San Diego are not apparently flooded but it is quite possible that this bay as well as Falso bay has been formed by this very recent depression. The fact that we do not know just how much the recent subsidence has been makes it difficult to discriminate with certainty between the erosion of the early Pleistocene and that preceding this depression, but I think we are justified in assuming that the broad and flat baseleveled valleys with allu-

vial bottoms above the points of flooding were excavated out of the Pliocene or older strata, as the case may be, during an early Pleistocene elevation.

The plains of Los Angeles stretch from Newport north to Santa Monica broken chiefly by the San Pedro hills. The plains are underlaid by a very considerable thickness of Pliocene deposits, with Pleistocene on the surface. The submarine valleys at Newport, Redondo and Santa Monica must have been excavated chiefly in the Pliocene strata. The landward prolongation of these valleys was of course obliterated in the recovery from the Pleistocene depression. The mouths of nearly all the streams in this section, as along the coast of San Diego county, are more or less flooded. It is possible that the recent depression of about 350 feet which Mr. W. S. T. Smith recognized on Santa Catalina island is the same as that shown by the small submarine valley at Newport, opposite the mouth of the Santa Ana river, which is not apparent at the depth of 100 fathoms but extends very close to the shore.

The valley of the Santa Clara river has a general east and west direction curving toward the south near its mouth where the alluvial plain is many miles wide. The higher hills on either side are Miocene while the lower belong to the Pliocene. According to Mr. Watts* the valley is not a structural one but due to erosion. It is baseleveled for 30 miles from its mouth but the depth of the Pleistocene forming the bed on which it flows is not known. The submarine valley corresponding to this, as before remarked, comes very close to the shore. It must be in great part cut out of the Pliocene filling of the post-Miocene erosion valley. There is no reasons whatever for supposing that the deep and narrow valley could in any way be formed by the deformation of the Pliocene.

No more large streams are met until western Santa Barbara county is reached. Here the Santa Ynez and the Santa Maria enter the ocean with alluvial bottoms 10 and 5 miles wide respectively. No submarine valleys are known opposite these rivers. It is possible that with the last uplift the channels were filled pari passu with the emergence of the land. Both of these streams flow over sandy or gravelly beds for many miles back from their mouths. The Santa Ynez has a general course fol-

*Verbal communication.

lowing quite closely the post-Miocene folding of this region and we have no direct evidence yet as to the relative importance played by structure or erosion in its formation.

The Santa Maria has a very irregular course, much of its channel having been cut across the structural features of the mountains. The broad bóttom of this valley extends back from the ocean for a distance of 20 miles with a grade of about 20 feet to the mile. At Fulger's point it issues from the Cuyamas canon, uniting at the same time with the Sisquoc. Both streams are baseleveled still many miles above the junction. This feature is particularly noticeable in the Santa Maria which has cut directly across the mountains through the Jurassic, Cretaceous and Miocene strata. The baseleveled condition extends into the canon for about 15 miles, the bed of the stream being quite broad but bordered by steep mountains, and the waters everywhere flowing over a sand bed. There can be no doubt that to stream erosion is due the broad lower portion of the Santa Maria valley as well as the upper portion. It has clearly been cut out of Miocene rocks at its upper end, as well as near its mouth, where, on the south side the Miocene rocks forming a part of Point Sal rise very abruptly and dip away. Through the most of the first 20 miles of its course the river is bordered by low hills which are in part of Pliocene age or even younger. The numerous wells 200 to 300 feet deep sunk in various parts of the broad valley have pierced layers of gravel, sand and clay which are apparently entirely undisturbed having a dip corresponding to the alluvial surface. These deposits are in all probability very deep and resemble in every character those of known Pleistocene age in the other large valleys of the state. We can thus distinguish here two periods of elevation, one following the Miocene, the other the Pliocene.

From Santa Maria north to Carmelo numerous streams have cut transverse valleys in the Coast Ranges but none of these have a very large watershed. San Luis Obispo, Morro, San Simeon and numerous other small creeks, as well as the arroyos La Cruz and Corpo Joro and the Sur river all clearly show at the points at which they enter the ocean indisputable evidences of a former elevation. The lower portions of all these streams flow over gravelly beds in alluvial bottoms

sometimes one half a mile wide. The very recent subsidence is shown by tidal lagoons at the mouths of many of these streams. This character appears most distinct with those streams which at present are not transporting much detritus. Morro bay has the character of a sunken area and probably dates from this last depression. The existence however of alluvial bottoms of very considerable depth above the extreme lower portions of the streams affected by the last subsidence must be taken as indicative of an earlier Pleistocene elevation. All the streams along this part of the coast have eroded their channels in Miocene or older strata unless it be with the exception of the Arroyo Grande which in its lower portion is bordered by more recent formations.

In the course of a geological study by the writer of the Buchon range west of San Luis Obispo some facts strikingly corroborative of a recent depression have recently been brought to light. It seems that in the case of two small creeks, their present valleys, eroded in the Miocene shales, extend beneath the ocean to a considerable distance. The mouth of one of these streams, Islay creek, where it enters the ocean between cliffs of shale has been filled up to base level with gravel, but soundings undertaken for the purpose of making a landing show an extension of the narrow land valley, to at least a distance where the water is seven or eight fathoms deep. It may extend further, but no effort has been made to trace it. The course of the submerged valley is beautifully shown during rough weather by the breakers on either hand. The slope of the bed of the creek back from the ocean appears to extend unbroken beneath the water, and this taken in connection with the fact that the cliffs are being rapidly eaten into and undermined leads to the conclusion that the subsidence is very recent.

Professor Lawson has interpreted the conditions at Carmelo bay as pointing definitely to the fact that the coast has never been elevated more than at present since the post-Miocene upheaval. To my mind the conditions lead to the opposite conclusion.

San Jose creek enters the ocean through a flat which certainly has been excavated at some time below the present ocean level, and the depression agrees in position with the ex-

tension landward of the deep submarine valley forming the southern side of Çarmelo bay. I cannot conceive of the conditions under which a fault might occur which would give the bottom the character shown, without a period of subaerial erosion. The Carmelo river is spoken of by Lawson as base-leveled only in its lower stretches. On the contrary its broad sandy bed extends back 15 miles. Lawson holds also that because the mouth of the Carmelo river lies between granite outcrops not more than one-eighth of a mile apart the bed-rock can be only a short distance below, and that consequently the elevation of the coast never could have been much greater. This conclusion does not necessarily follow for the bed-rock may be much deeper than supposed, and besides there is another possibility. During the early Pleistocene elevation, and before the formation of the modern terraces the river may have emptied into the ocean north of Abalone point. The general character of the river bottom is most suggestive of a very considerable elevation during the early Pleistocene.

If professor Le Conte is correct in supposing that at one time the outlet of the great valley of California was into Monterey bay, ths size of the submerged valley at that point is easily accounted for. The Salinas river, however, is of no mean size, and during a portion of the year carries a large body of water. There can be no doubt whatever that at the mouth of this river the Miocene bedrock is at a great depth, and consequently the post-Miocene disturbance could not have been the origin of the submarine valley, as professor Lawson thinks. He* considers the Salinas valley to be a valley of erosion along a fault line and cut out in pre-Pliocene times. With the latter thought I am in accord, but that would necessarily demand that the pre-Pliocene elevation should have been much greater than the present, which conclusion is contrary to the opinion of the author just referred to. A deep well has been bored near the town of Salinas, which lies in the centre of the valley a few miles from the ocean. The material passed through is quite similar to that in some of the other large valleys, which is considered to be of Pleistocene age. With the Pliocene depression the valley must have been partly filled, and with the following early

*Bull. Dpt. of Geol. Univ. of Calif., Vol. I., p. 155.

Pleistocene elevation again excavated and in the recovery from the terrace period filled to the present level. The fact that the submarine valley extends close to the shore directly at the mouth of the present river makes it very certain that its upper portion must be excavated in the Pleistocene sediments and at a very recent epoch.

Indications of a recent subsidence are plainly visible near the mouth of the Pajaro river. A tidal lagoon extends northerly from a point west of Castroville for about ten miles. The lagoon is bordered by low hills of unconsolidated material, probably of Pleistocene age. The slopes of the hills facing the old channel show plainly the effects of erosion during a greater elevation, for it is inconceivable that it could have been excavated under present conditions.

Although the Pajaro river flows out to this ocean through a narrow canon on leaving the Santa Clara-San Benito valley, this fact cannot be used as an argument against the view that the Sacramento river once emptied here. The narrow and steep walled gorge has been cut very recently, possibly as a result of local warping. The hills immediately adjoining the canon on the south do not rise over 300 feet and are of recent formation.

The character of the broad valley north of San Pedro point is indicative not only of the recent subsidence which Lawson considers has affected the region about the bay of San Francisco, but of a very considerable elevation prior to the formation of the terraces.

From the foregoing considerations it is evident that the last depression has not been so local as Lawson has supposed. It is seen to have affected the most, if not the whole, of the southern coast. The negative evidence, according to Lawson, north of Bodega Head is not of great value, for the mountains generally come down quite abruptly to the coast. The flood plain described by him at the mouth of Eel river is strongly suggestive of a recent depression; at least I do not see any reason why the phenomena might not be interpreted as easily that way as any other. Lagoons occur at the mouths of Smith and Klamath rivers, but this region has not been studied.

A recent subsidence is plainly recognizable along the Ore-

gon coast according to Mr. Diller. He says:* "The last movement of the land by which the Oregon coast came to its present position was one of subsidence. This movement had a marked effect upon the rivers. They are drowned on the lower portions of their courses, and the tide comes far inland." The last subsidence is thus seen to have been a general one. There is no doubt that in certain places on the California coast, as at the Golden Gate, it is more pronounced and noticeable.

It might be argued from the character of the large valleys opening out through the Coast Ranges to the ocean that we have no definite means of discriminating the Pleistocene from the Pliocene, that the latter may be encountered only a slight distance below the surface, and that no reliable evidence can be gained from the study of this aspect of the supposed post-Pliocene elevation. Does the Pleistocene occupy a depression eroded out of the Pliocene which it is believed filled or partly filled the most of the older valleys of the Coast Ranges? It is admitted that much of the needed information is at present lacking, but there is nevertheless some of great value at hand. In the first place the Pliocene is found to be more or less tilted and faulted wherever it occurs, the Pleistocene on the contrary has simply been elevated in the epeirogenic movement of the coast without any other noticeable disturbance. From the Santa Ana plain on the south, to the region about San Francisco bay, wells possessing more or less of an artesian character have been found in the most of the larger valleys. The record of the material passed through in drilling these wells has been kept in many cases and it appears that it is generally quite uniform. It consists of unconsolidated gravels, sands and clays. Where fossils have been found, as in the Santa Clara valley and the Great valley, the strata are distinctly shown to be of Pleistocene age. Their position is somewhat basin-like and so entirely undisturbed that with some experience it can often be told quite definitely how deep certain strata lie in different parts of any particular valley. If the beds were of Pliocene age we know that this regularity would not be found to exist. I believe then that we have a right to extend our generalization from these valleys where fossils have

*17th Annual Report of the U. S. Geol. Sur., p. 50.

been found to others where we know the character of the strata but have no record of fossils. I think then that we can lay it down as a general fact that all the stream valleys opening out to the coast are filled to a very considerable depth with undisturbed deposits of Pleistocene age. In the plains of Santa Ana and Los Angeles artesian wells are found several hundred feet in depth passing through unconsolidated material. In the Santa Maria valley the wells reach down 200 to 300 feet passing through sands and gravel having the same almost level position as the surface of the valley. How much deeper this formation is we of course do not know. In the valleys of the Salinas and a few miles from the ocean is a well, reaching a depth of 1300 feet. The character of the strata passed through seems to be very similar to that shown by the deep wells of Stockton where they are believed to be of Pleistocene age. From Watsonville west to the ocean are artesian wells 70 to 256 feet deep lying in the flat bottom of the Pajaro valley. Numerous artesian wells have been put down the whole length of the Santa Clara valley and on both sides of the southern arm of San Francisco bay. They vary in depth according to position from 100 to 700 feet. Remains of Pleistocene mammals have been obtained in addition to marine and fresh water shells.

I think that in general there can be no doubt that these wells are confined to the undisturbed Pleistocene beds filling the earlier eroded valleys. The water coming down the present streams begins to percolate downward, as soon as the bedrock is passed, into the sand and gravels, the sedimentation lines of which conform to their original slightly sloping position, the position in which they were deposited during the greater elevation of the early Pleistocene. The beds of coarse sand, pebbles and sometimes boulders passed through in the Salinas well as in the Great Valley indicate that deposition followed close upon subsidence, and that a much greater elevation must have existed.

Conclusion.

It is believed that the above discussion has completely substantiated the view first advanced by professor Le Conte of a greater elevation of the coast during the early Pleistocene.

The difficulty of always being able to discriminate between the effects of the different movements is not overlooked, or the possibility of their being more complex than at present believed. It will be perceived that this view introduces another complete vibration, making two where professor Lawson has one, and appears in a general way to harmonize the movements on the Pacific coast with those recognized by many students in other portions of North America.

The marked orogenic disturbances which accompanied the epeirogenic movements at the close of what has been termed the Miocene, as well as those which have been considered as limiting the Pliocene in the Coast Ranges, should continue to be used as in the past to set off the rocks of these periods. These disturbances were accompanied by lava flows and resulted in marked nonconformities. The intensity of the orographic movements varied along the 800 miles of the California coast, and in the interior, so that owing to different conditions of life, as well as to this intensity, the number of extinct forms in the different beds, particularly in the Pliocene, show a considerable variation. The total outcome of the movements because of their local intensification has resulted in the elevation of Miocene strata over 6000 feet in portions of the Coast Ranges, while to the south near San Diego strata of that age are apparently absent.

It is believed that the various lines of evidence presented in regard to a supposed post-Pliocene uplift are incontrovertible, and that the disturbances recognized by all as occurring at that time could not have left the general level of the coast less than 1000 feet and probably much more than that, above the present, and that the upturned Pliocene beds were truncated by subaerial erosion previous to the terracing. This elevation must have been sufficient and perhaps much more than sufficient to permit of a connection of the Santa Barbara islands with the mainland. The movements of the islands also seem to have corresponded very closely with those of the mainland.

It is believed that the submarine valleys are in most cases if not in all explainable by no other hypothesis than that of subaerial erosion; that without doubt such valleys were formed following the post-Miocene uplift, or what is quite within the bounds of possibility earlier still, but that their final form,

aside from subsequent modification by sedimentation, was given them during the post-Pliocene elevation which the steep character of the valleys would appear to indicate was of no great duration geologically speaking. The lack sometimes of correspondence between these submarine valleys and those of the present streams may be due in part to changes in the land topography and in part to local conditions during the rising and sinking.

The more important movements of the coast during the time under discussion are believed to have been as follows.

(1) Post-Miocene disturbance, resulting in an elevation much greater than the present, and outlining during the resulting erosion many of the present land features and originating or enlarging some of the marine valleys.

(2) Pliocene depression and accompanying sedimentation in favored localities.

(3) Post-Pliocene disturbance accompanied with folding, faulting and upheaval to a greater elevation than the present; a movement probably felt in the Sierra Nevadas and resulting finally in the glaciation of that region. During the erosion of this early Pleistocene the existing valleys of the Coast region were wholly or partly re-excavated in conjunction with the present marine ones. During the period of elevation, probably not later than the middle Pleistocene, the mammoth and other extinct mammals occupied the Pacific coast and spread over what are now known as the Santa Barbara islands.

(4) After a comparatively brief period as shown by the steepness of the submerged valleys a downward movement began and continued until the land was at 1200 to 1500 feet below the present.

(5) In the recovery from this sunken condition the terraces were formed and an elevation reached which was somewhat greater than that now shown.

(6) Last of all took place the subsidence recognized by Mr. Diller in Oregon, by professor Lawson at the Golden Gate and by the writer along the coast to the south.

A present discussion of this subject must be far from exhaustive and future study may bring out modifications of the above outline, but it is hoped that some permanent addition has been made to the knowledge of the history of this region.

THE PHYSIOGRAPHIC DEVELOPMENT OF THE UPPER MISSISSIPPI VALLEY.

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The Cretaceous period was characterized, on the site of the present Mississippi valley, by the most favorable conditions of widespread baseleveling. The land, never greatly elevated, stood at a nearly permanent level with relation to the sea, during the entire time, enabling the streams to so widen their valleys and surface erosion to tear down the divides, that the entire land area, long before the close of the period, had assumed the attitude of a low-lying, very slightly undulating plain, rising gently from the sea coast to the most distant interior parts. Over the outcropping areas of limestones and soft shales and sandstone, which then underlaid the surface from the granites and quartzites of the central area of Wisconsin and northeastern Minnesota, to the Archean belt (now partly buried under later strata) which lies south of the southern Appalachian and Ozark provinces, this Cretaceous peneplain must have been one of a remarkably even character.

During the later or upper Cretaceous time, the sea on the west was gradually encroaching upon this great baseleveled plain. Possibly slight warpings along the coast or the marine erosion of small sea-cliffs, enabled the streams near their *embouchure* into the sea, to excavate slight channels, not sufficient however, to materially interfere with the plain-like character of the land surface. As the Cretaceous waters took possession of wide stretches of nearly level land, they deposited fine sediment in thin strata, first in the slight valley troughs, and then upon the general flat surface of the interstream portions. Since the close of the period and the disappearance of the sea from the Mississippi basin, subaerial erosion, supplemented in the north by glacial abrasion, has generally removed the soft Cretaceous strata from the areas where they never existed in great thickness. But here and there an isolated outlier remains in the shallow depressions, indicating the former extent of marine strata of this age. By this means, the geologists of the Minnesota survey have been enabled to determine that at the time of maximum submergence in the Cretaceous period, it is doubtful if any large body

of land, now included in this state, remained above the sea-level, except perhaps the extreme northeastern portion of it.

The isolated outliers which, in Minnesota, indicate the former extent of the sea, have all been demonstrated to be upper Cretaceous in age. They have lithologic characters peculiar to the product of this period, and, moreover, contain a fossil fauna and more especially a flora which fix their age beyond any doubt. Now, it is obvious that the rock surface upon which these strata repose represents approximately the land surface of the later portion of the Cretaceous period. I say *approximately*, because there may have been slight marine erosion of the land surface at the time of its submergence. But the shallow depressions or valleys in which these strata rest show that there was not formed a well-marked submarine shelf. Hence, we may consider the surface upon which these strata lie, as representing the present attitude of the Cretaceous peneplain.

By a careful study of these outliers and the altitudes which they now attain, we may learn of the amount of deformation which this, at present much dissected peneplain, has suffered, and also secure data for its location in neighboring states. This is the primary object of this paper.

*Peneplains of southeastern Minnesota.** Cretaceous impure lignite with associated fossiliferous clays, outcrop in the west bank of the Mississippi river, at the mouth of the Two Rivers in Morrison county, central Minnesota. They are of fresh water formation, but fix the position of the peneplain almost as definitely as do those of marine origin. The altitude of the mouth of the Two Rivers is about 1034 feet above the sea. The outcrop of Archean staurolitic schist and diorite at various places along and close to the river but never high above it, within the county ten miles northward, seems to indicate that this is approximately the altitude of the dissected Cretaceous peneplain in this vicinity.

In the counties of Hennepin, Ramsey, and Dakota, which adjoin each other at the junction of the Minnesota and Miss-

*The information concerning southeastern Minnesota has been derived largely from the maps accompanying Vols. I and II of the reports of the Minnesota geological survey. These maps, although never intended to represent all the minute details of the topography, are yet sufficiently accurate for the purpose to which I have applied them.

issippi rivers, there are, under the thick drift of this region, isolated areas of Trenton shales and underlying strata which rise to nearly a common level forming an almost destroyed plain which has an average altitude of slightly less than 900 feet above the sea. Over northern Dakota county and southern Ramsey, the soft Trenton shales which form these buried upland areas, are not capped by any specially resistant stratum, removing their summit plane from the category of structural plains. As, also, higher strata of Silurian age undoubtedly existed over them at one time, we can only explain the existence of the plain at the present time, under the hypothesis that it represents a baselevel of erosion—in fact, constitutes the remains of a nearly destroyed peneplain. Now, marine Cretaceous strata outcrop along the Crow river in Hassan township, in the northwestern part of Hennepin county, at an altitude of about 900 feet above the sea. This indicates that the 900-foot plain in the vicinity of St. Paul and Minneapolis corresponds to the land surface of late Cretaceous time, so that it deserves to be known as the *Cretaceous peneplain.*

In going southward across Dakota county, we find that the rock surface of the general upland rises slightly so that while it is less than 900 feet near St. Paul, it is from 950 to 1000 feet above the sea in the southeastern corner of the county. We shall next pass into Goodhue county, lying south and southeast of Dakota county, which is for our purpose one of the most interesting in the entire state. The general upland surface near the cañon valley of the Mississippi river, is a slightly undulating plain rising gently and evenly from an altitude of 950 to 1000 feet in the northern portion where it connects with the Dakota county plain, to 1100 feet above the sea in the southeastern portion of the county. In northern Dakota and Ramsey counties, because the peneplain was underlain by soft Trenton shales 75 to 125 feet in thickness, it has been nearly destroyed, but in Goodhue county and southeastward, its underlying strata (the Lower Magnesian series), being more resistant, it is represented by a great number of flat-topped ridges separated by comparatively narrow valleys or cañons often 400 or more feet in depth. In the southern portion of the county, the Trenton limestone underlies the surface and forms a plain which is only slightly higher than the Low-

er Magnesian plain which adjoins the cañon valley of the great river.

In Goodhue township, about 12 miles southwest of lake Pepin, quite an extensive outlier of Cretaceous strata has been mapped by the Minnesota survey. It is surrounded by outcropping St. Peter sandstone and Shakopee limestone. Contours of 1050 to 1150 feet above the sea cross the area mapped as Cretaceous. The general upland plain, here about 1100 feet above the sea, seems to pass across these strata, but in the text we learn that the hight and topography of this area are similar to those of the "Trenton plain" on the west, so that it seems to be an outlier of an upland surface which has been destroyed eastward from it, but is represented by the Trenton plain. Now, whether we recognize the Trenton plain as due to structural features or not, the presence of the Cretaceous strata proves that it corresponds approximately with the uplifted, deformed and widely dissected Cretaceous peneplain. It is also quite clear that there being no lower peneplain than the Lower Magnesian plain near the Mississippi river, if any Tertiary peneplain is here represented, it must be very nearly identical in altitude with the Cretaceous peneplain.

We will now go eastward into Wabasha county. The general upland or Lower Magnesian plain near the river, has an altitude of 1100 feet in the country west of lake Pepin, but rises gently to about 1200 feet above the sea in the southeastern corner of the county. In Olmsted county, which is directly south of it, the Trenton plain which, in Goodhue county, was scarcely distinguishable from the Lower Magnesian plain so far as altitude was concerned, now rises into a plain which is distinctly higher than the other. It attains an altitude in the south portion of the county of about 1300 feet above the sea. Beyond its eastern outcrop or escarpment, isolated areas of the Trenton rise like "mounds" from a lower plain, notably Lone Mound near Potsdam.

In Winona county, which lies between Olmsted county and the Mississippi river, the upland forms one or more dissected plains, which have an average altitude of 1300 feet above the sea in the southwestern corner of the county, where the Trenton plain appears, and 1200 feet eastward from the Trenton

escarpment to the verge of the Mississippi cañon valley, and the same across the Lower Magnesian plain northward to the north line of the county. The cañon valleys are trenched from 400 to 450 feet beneath the surface of the plain, except along and near the Mississippi river where their depth is nearly 600 feet. In Houston county, which is the most southeastern in the state, and lies southeast of Winona county, the Lower Magnesian plain is represented by most of the upland ridges, which stand about 1150 feet above the sea, rising to 1200 feet in portions of the county. These upland ridges form a nearly level dissected plain which terminates abruptly near the verge of the Mississippi cañon valley. It is cut by the deep valleys of streams tributary to the large river, but proportionately slightly wider than the great cañon. The water level is about 620 to 700 feet above the sea, the main valleys being thus about 500 feet in depth. The Lower Magnesian plain slopes gently westward, with the dip of the strata, ten miles to the foot of the Trenton escarpment, where the surface rises abruptly 100 feet to the top of the Trenton limestone, and then by a more gentle slope of 50 to 75 feet, reaching the level of the Trenton plain about 1325 feet above the sea, or about 150 feet above the lower plain.

In going westward from Houston county, we again get into very interesting territory. In Fillmore county, the general upland surface averages 1200 feet above the sea, except on the Trenton limestone areas, where it rises abruptly to 1300 or 1350 feet. Trenton outliers stand on the lower plain somewhat as do the "mounds" in the lead region of Wisconsin, Iowa, and Illinois. They are known as "Trenton mounds." In the western portion of the county, the nearly level plain which forms the surface of the Trenton areas, passes across the intervening strata on to the Devonian limestone, without any deformation. Perhaps I should say that while both the Devonian and Trenton plains may be "structural" in origin, their surface corresponds in altitude, forming a practically continuous dissected plain, having a general altitude of 1300 to 1350 feet above the sea, suggesting that they may have been formed under the same conditions as a true peneplain. This apparent peneplain is not confined to one county, but passes westward across Mower county, gently declining in

that direction and southward into Iowa, where it becomes the surface of the well-marked topographic feature, the Niagara plateau. We shall now see whether there is any further evidence of its having originated under baseleveling conditions.

Cretaceous strata are not well exposed, but are probably developed with considerable areal extent in the southwestern corner of Fillmore county, where they overlie Devonian limestone at an average altitude of 1300 feet above the sea. The lower portion, as the Minnesota survey report says, "consists of sandstones and lignitiferous clays or shales, the sandstones lying at the base of the formation, and being the same that Dr. White has denominated in Iowa, the Nishnabotany sandstone, and belonging to the Dakota group of Messrs. Meek and Hayden." This sandstone so far as observed has a thickness of about 100 feet. The shaly member above the sandstone has been identified by Mr. F. B. Meek as the Fort Benton group of Messrs. Meek and Hayden. Cretaceous strata are also mapped in the eastern part of Mower county, near Hamilton as overlying Devonian limestone at about 1300 feet above the sea. Near Austin in the western part of the county they are represented as occurring over Devonian shale and sand-rock at an altitude of about 1150 to 1200 feet above the sea. It thus seems evident that the 1300-foot plain in Fillmore and eastern Mower counties, because of its possessing extensive outliers of marine Cretaceous strata of the age of the earlier portion of upper Cretaceous time, represents approximately the land surface on which, after its submergence, the ancient sea deposited its sediment, and that therefore it deserves to be known as the Cretaceous peneplain. This ancient plain slopes northwestwardly, being represented in western Mower county at about 1200 feet and in Brown and Cottonwood counties it must pass beneath the Cretaceous strata, which are mapped in the Minnesota valley by Upham at levels between 800 and 900 feet above the sea. This is, also, approximately the altitude of the top of outcropping areas of Archean granite and gneiss throughout the upper Minnesota valley. The highlands south of this depression are heavily drift covered, but the *coteau des prairies* is known to consist largely of Cretaceous strata.

In recapitulation of the results of this investigation into

the topographical development of southeastern Minnesota. we will begin in the southeastern corner of the state. Here, as we have just seen, the Cretaceous peneplain is represented by upland areas which now attain an altitude of 1300 or more feet above the sea. This plain must have originally extended to and across the present course of the Mississippi, rising slightly in that direction; but it has been almost completely destroyed throughout the country east of the Trenton escarpment, by erosion subsequent to the uplift of the upper peneplain. This new cycle of erosion resulted in the formation of a new peneplain about 150 feet lower than that of Cretaceous age. This new peneplain, (whose existence as such is not doubted by most students of the upper Mississippi region) being of later age than the Cretaceous may be designated as the Tertiary peneplain. The newer baseleveled plain which has an altitude of about 1200 feet in the southeastern corner of the state, slopes gently and evenly northwestward to about 1050 feet above the sea in Goodhue county. Returning now again to the Cretaceous peneplain we find that it slopes northwestward also gently and evenly, but at a rate slightly greater than the Tertiary peneplain, the result being that in Goodhue county, where its position is accurately fixed by an extensive outlier of Cretaceous strata, it is but little higher than the Tertiary peneplain. Still farther northward in the vicinity of St. Paul, the two peneplains have merged so completely that either name may be applied to the 900-foot plain with equal propriety. Northward from Hennepin county the Cretaceous peneplain again rises, but the country being heavily drift covered the Tertiary peneplain is unrecognizable, if, indeed, it is not identical with the Cretaceous.

Sometime after the termination of the Cretaceous submergence of southeastern Minnesota, the land was elevated by a differential uplift. In the extreme southeastern corner of the state the elevation was sufficient to enable the streams to lower their channels to about 150 feet beneath the Cretaceous peneplain. But in the Minnesota depression which extends east and west across the south central portion of the state the uplift was not sufficient to seriously affect the stream level. Hence, we may infer that about St. Paul and westward in the line of the structural depression just mentioned, the land sur-

face was a low-lying plain through nearly the whole of the Tertiary era. This idea is, I understand, in accordance with the opinion of Messrs. Hayes and Campbell, and of the geologists of the Minnesota survey. This long period of baseleveling was suddenly terminated by the most profound movement of elevation which has affected the territory since the Paleozoic era, enabling the streams to dissect the upland peneplain by cañon valleys from 400 to 700 feet in depth, (excluding the, at present, buried portions).

*Peneplains of northeastern Iowa.** Crossing the state line into Iowa, we find the main topographical features of the territory whose investigation has just been completed, continued and even better defined than in the more northern district. In the northern one-third of Allamakee county, the Tertiary peneplain is underlain by the St. Peter sandstone, but over the remainder of the county, the Trenton group forms its nearly level surface. The altitude averages 1200 feet above the sea, and hence the cañon valleys which, in this county, have tortuous courses suggesting an origin from the meanders of the streams on the peneplain before uplift, are nearly 600 feet in depth. A few mound-like elevations reaching 1300 feet above the sea occur on a ridge trending northeast from near Ludlow. Going westward into Winneshiek and Howard counties, we rise rather abruptly to the surface of the Trenton plateau, having an average altitude slightly exceeding 1300 feet above the sea. This plain is indistinguishable so far as altitude is concerned from the surface of the Niagara strata west of it, which latter also merges into the plain of the Cedar Valley limestone. The surface of these three limestone formations together constitute the 1300-foot plain or plateau in distinction from the 1200-foot plain or Tertiary peneplain east of the Trenton escarpment. Now, in the vicinity of Foreston and Lime Springs, in northern Howard county, Cretaceous strata occur with characters which demonstrate their affinity to the strata of practically the same age outcropping in Minnesota on this same 1300-foot plain. This Cretaceous

*The information concerning northeastern Iowa was derived largely through a study of the fine hypsographical and geological maps, (supplemented by the admirable descriptions contained in the text) accompanying Dr. W J McGee's excellent memoir on "The Pleistocene History of Northeastern Iowa," in the XIth Annual Report of the U. S. Geol. Survey.

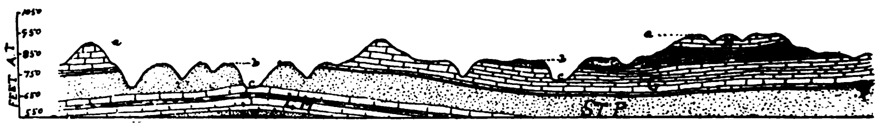


FIG. 1.—SECTION DRAWN NORTH AND SOUTH ACROSS THE BASINS OF THE LEAF RIVER AND ELK HORN CREEK IN NORTHWESTERN ILLINOIS.

LEGEND—a, Tertiary peneplain. b, Lafayette base level. c, Present stream level. N, Niagara limestone. H R, Hudson River shales. G, Galena limestone. T, Trenton limestone. ST. P, St. Peter sandstone. L M, Calciferous limestone and shale. P, Potsdam sandstone.

outlier in Iowa is important as corroborating the evidence previously presented of the practical correspondence between the apparent structural plains represented by the Trenton and Niagara outcrops in this portion of the Mississippi basin, with the ancient land surface which has been designated the Cretaceous peneplain.

Southward from Allamakee county to the Turkey river, the upland within 20 miles of the Mississippi river, consists of the flat topped ridges whose crests merge, in the far distance, into an even sky-line—the remarkably even surface of the ancient Tertiary peneplain. It passes from the Trenton limestone on to the Galena limestone, and bevels the edges of the latter. It also slopes gently and evenly in this southward direction, to about 1,000 feet above the sea near the mouth of the Turkey river. It extends almost to the very verge of the cañon valley of the Mississippi and beyond this stream it forms the general upland surface throughout southwestern Wisconsin. Because of its ignoring the gentle folds of the indurated formations, its passage without deformation from one terrane to another, and its even sky-line in the far distance, it is generally recognized as a dissected base-levelled plain regardless of the fact that some portions of it present as strong evidence of being "structural plains" as any in America.

Returning now again to our 1300-foot plain, in tracing it southward from Winneshiek county, it becomes the well known Niagara plateau of northeastern Iowa, whose eastern limit is the Niagara escarpment, the most prominent topographical feature of the territory. This plateau gently declines southward, until near the mouth of the Turkey river, its altitude slightly exceeeds 1200 feet. The escarpment which bounds it is nearly everywhere precipitous, but is deeply cut by val-

leys, giving the border of the plateau a crenulate outline. These marginal ridges do not form a perfectly even plain, but they do not appear to reflect the attitude of the slightly corrugated strata as perfectly as a mere structural plain should. The summit line of the escarpment gradually rises, with reference to the Tertiary peneplain east of it until, near the mouth of the Turkey river, there is a vertical difference between them of about 200 feet.

The Niagara escarpment which approaches very close to the cañon valley of the Mississippi river, south of the mouth of the Turkey river, again recedes from it, and in northeastern Dubuque county, the Tertiary peneplain is developed over a width of 10 or 12 miles. It is interrupted however, by outliers of the Niagara plateau of which Sherrill mound is the most prominent. At the city of Dubuque, the Tertiary peneplain is represented by the general upland surface at an altitude of about 900 feet above the sea. Half a dozen miles westward from the city, the Niagara escarpment is seen, with a concentric course, bounding the plain like the perpendicular walls of a high crater. Its crest line is remarkably even if it represent a structural plain, for it is crossed by a number of slight anticlinal folds. The nearly level plateau whose eastern border this escarpment is, has an altitude which barely reaches 1200 feet above the sea, or something over 250 feet above the Tertiary peneplain east of it. The Niagara plateau slopes gently westward, and is overlain near Rockville in Delaware county, by a gravel formation which McGee has provisionally correlated with the Cretaceous strata of southeastern Minnesota. This correlation being probably correct, seems to indicate that the Niagara plateau in Dubuque and Delaware counties is not merely a structural plain, but also corresponds with the land surface of the Cretaceous period. In fact its extension without any decided change in altitude and only a slight and gentle slope, from the undoubted Cretaceous peneplain of southeastern Minnesota and Howard county, Iowa, warrant our reference to it as the Cretaceous peneplain. This peneplain everwhere slopes westward, which is necessary that it may go under the Cretaceous strata in the western part of the state.

Southward from Dubuque, the Niagara plateau sends sev-

eral spurs almost to the very verge of the cañon valley of the Mississippi river. They form heavily wooded, even-crested ridges which rise nearly 500 feet above the stream. Southward from the northern portion of Jackson county the Niagara plateau disappears, and the hard limestones of this formation constitute the general upland areas whose surface represents the Tertiary peneplain. This extends with an average altitude of 900 feet above the sea but a slight southward slope, to the northern edge of the broad basin occupied by the lower course of the Wapsipinicon river.

Peneplains of northwestern Illinois.—Upon crossing the Mississippi river into northwestern Illinois, we find the Tertiary peneplain well represented by the general upland surface. In Jo Daviess county it slopes perceptibly toward the southwest from an axis of deformation which crosses the Wisconsin-Illinois line near Warren, and trends southeastward. Throughout this region the peneplain corresponds approximately with the surface of the Galena limestone, but in Stephenson county it bevels the edges of the slightly tilted strata of that formation, cutting away 100 feet of it, ten miles east of Freeport. Yet the sky line of the upland areas remains remarkably even, indicating that, before the uplift, deformation, and dissection of the peneplain, it was about as flat as a plain of denudation can well be. In northern Carroll county, its southwestward slope is quite perceptible, but it maintains an altitude of nearly 900 feet above the sea into the northern part of Whiteside county. This is another area where the original altitude of this peneplain must have been remarkably even, yet it is underlain by the Galena and Niagara limestones, and the Hudson River shales, never indicating their difference by any inequality of surface.

The Niagara plateau with its outliers or "mounds," which we left in Iowa, ending abruptly near the Mississippi river in a steep, crenulate escarpment, reappears in Jo Daviess county, Illinois, where it is first represented by Pilot knob, a prominent cone-shaped elevation, near the mouth of the Galena river. This rises to about the same altitude as the Niagara plateau in the adjoining portion of Iowa. The central portion of the county is a dissected plateau, or rather a series of small plateaus which do not differ from the Niagara plateau

of Iowa except in areal extent. These plateau masses form a dissected plain as perfect as the Niagara plateau in Iowa. Around their western, northern, and eastern borders there are outliers in the form of "mounds," some cone-shaped and others elongated into short flat-topped ridges. The larger of these "mounds" attain practically the same altitude as the neighboring plateaus, and their summits are evidently parts of the same dissected plain. Imagining for a few moments, that all the strata which have been removed from between and around these "mounds" and plateaus be restored, we would see the land surface as a very slightly undulating plain, sloping gently from an altitude of about 1275 feet on the Wisconsin line to 1100 feet near the mouth of the present Galena river, and 1050 feet above the sea in Stephenson county near the village of Eleroy. This plain would be continuous, without any deformation whatever, with the Niagara plateau in Iowa. It would also sink, with reference to the Tertiary peneplain, from about 250 feet along the Mississippi river near Dubuque and 275 feet in Jo Daviess county near Scales mound, to only 125 feet in Stephenson county near Eleroy. Furthermore, its surface would not reflect the slight folds of the indurated formations, several of which cross the area of the plateaus. But more remarkable than anything yet stated, the Niagara limestone would thin out under this plain toward the east, until in Erin township, Stephenson county, less than a dozen feet of Niagara limestone would remain, although the formation occurs even now in much greater thickness under the Tertiary peneplain, less than ten miles south.

Whether we consider the summit level of the Niagara plateaus and outlying "mounds" in Illinois as a structural plain or not, the fact remains that they form parts of one great topographical feature of the upper Mississippi valley—a plateau extending from Goodhue couuty, in Minnesota, in a magnificent curved course, into Jo Daviess county, Illinois. It is everywhere bounded on its eastern and northeastern face by an escarpment, whose crest line gradually rises above the Tertiary peneplain to a maximum of about 250 feet near Dubuque and thence gradually declines again. Its western face has been obscured by heavy deposits of drift in Minnesota and in Iowa, except near the Mississippi river where it is appar-

ent, as also in Illinois. Its surface everywhere slopes from the inner to the outer side of the curve or away from some point in Wisconsin. It is the remaining portion of a great broad, but not high, dome-shaped "uplift" which centred somewhere in Wisconsin, but which has been completely removed throughout the country east and north of the Trenton and Niagara escarpments, unless possibly its surface may be represented by the summits of the Platte and Blue mounds in southwestern Wisconsin.

The concurrence of the surface of this great "uplift" with the Niagara limestone in Iowa, Illinois, and southwestern Wisconsin, and with the Trenton limestone in Minnesota, suggests that its characteristic features are due to structure and not to baseleveling conditions. But its failure to reflect the corrugations of the strata, and the thinning of the Niagara limestone at its eastern borders, which thinning is not similar to that of northern Iowa, there having originally been at least 200 feet of this formation over the Erin mound in Illinois, seem to indicate that it is a portion of a widespread peneplain which was uplifted differentially into a broad, low dome, and subsequently much dissected by erosion. It has been demonstrated that in southeastern Minnesota and extreme northern Iowa this supposed peneplain corresponds to the late Cretaceous baseleveled plain, while there is some evidence of Cretaceous strata on its surface as far south as Delaware county. I consider it a legitimate inference from the evidence that the surface of the Niagara plateau in both Iowa and Illinois everywhere represents the Cretaceous peneplain, so that a reference of the summit plane of the "mounds" in northwestern Illinois to this category is not mere hypothesis.

Since beginning my investigation into the character of the topographical features of the Mississippi valley, I have had constantly in mind the probability of many of the dissected plains which I encountered having been due primarily to the structural inequalities of the rock strata. But, although often corresponding to the surface of some specially resistant limestone, I have nearly always been able to trace these plains across the beveled edges of soft strata. And I have concluded that, in all probability, practically all of the extensive so-called structural plains of eastern America, are parts of one

or several widely developed peneplains. The conditions under which a "structural plain" is formed are limited, and unless it also corresponds to a basal plane of erosion, it will never have great areal extent. Peneplains are well developed where the strata removed above them were soft shales or but slightly indurated sandstones, and are best preserved where the strata under them are hard limestones or still more resistant formations.

The basin valleys of northwestern Illinois. In the small geographical district which is enclosed by the Mississippi and Rock rivers, and the Wisconsin line, there is a fourth class of topographical features which, although not confined to this area, is here quite prominent and easily studied. In southeastern Minnesota and northeastern Iowa, the cañon valleys seem to be trenched beneath the surface of the Tertiary peneplain which extends with its normal altitude nearly to the verge of the bluff. But in northwestern Illinois a long gentle slope intervenes between the edge of the higher upland ridges and the summit of the bluffs which bound the cañon valleys. These long slopes, on opposite sides of the streams, form broad shallow basin valleys, which are in strong contrast to the steep-sided cañon valleys trenched beneath their floors. The basin valleys are not confined to any formation, but their width varies according to the resistant nature of the strata excavated. When the strata removed in eroding them were the Galena or the Niagara limestone they are never more than two or three times as wide as the cañon valleys within them. But over the outcropping areas of the Hudson River shales, they occupy nearly the entire surface, sometimes even the main divides having been reduced from the level of the Tertiary peneplain. In the northern portion of the district the depth is often 100 feet, but in Whiteside county it does not much exceed 75 feet.

In the southern one-third of Stephenson county, where the Hudson River strata outcrop, a belt of country from five to ten miles in width, has been reduced below the surface of the main Tertiary peneplain, forming a lower, undulating, dissected plain, literally a small peneplain. Throughout one entire township in the southeastern corner of the county, the main Tertiary peneplain is represented by a single elevation—Bunker

hill. In the Leaf river valley, the basin valley averages several miles in width, bevels the gently inclined strata of the Hudson River shales, and passes, without deformation, through the Galena and Trenton limestones, on to the St. Peter sandstone. The Leaf river flowing eastward and the Elk Horn creek flowing southward actually rise in the same basin valley. The basin valley of Elk Horn creek, 2½ miles southwest of Foreston, is several miles in width, and its bottom is underlain, over extensive areas, by the St. Peter sandstone, the Trenton and Galena limestones having been removed from above it. The basin of this stream passes across the Trenton, Galena, Hudson River, and Niagara formations without the least deformation. In eastern Whiteside county, it broadens out to form a gently undulating dissected plain, which extends from Sterling, 15 miles north, and has a possible width of 10 miles. It resembles the main Tertiary peneplain, but has an altitude 75 feet lower, and is bounded on the east, north, and west by the higher upland areas which represent the upper plain. It bevels the edges of the gently inclined strata of the Galena and Niagara limestones, and the Hudson River shales. It is literally a peneplain.

At Unionville, in Whiteside county, we ascend out of the cañon valley of Rock creek, on to a dissected plain which borders the valley and averages 75 feet above it. A few miles northwest we have climbed a long slope on to an upland ridge which, upon tracing it northward, we find to be a remnant of the main Tertiary peneplain. It is here about 75 feet above the lower peneplain. We now travel northward on the "Mississippi divide," which is a broad flat-topped even-crested upland ridge trending north and south a few miles east of the Mississippi river. On our right is the broad shallow basin valley of Rock creek, trenched by its cañon valleys, and bounded on the opposite side by an even-topped upland area corresponding to that on which we stand. On our left every small stream, tributary to the great river, has its basin valley from one to two miles in width, separated from each other by even crested ridges which extend out as great spurs from the main divide. Some of these basin valleys are trenched into Niagara limestone, some into Hudson River shales, and still others into Galena limestone, but there is no difference between them except in width and in the state of their preservation.

In short, these basin valleys in northwestern Illinois are everywhere present, and such prominent features of the topography, that the observant traveler can not fail to notice them. In the country southward from Jo Daviess and Stephenson counties, they occupy three-fourths of the surface. All those which are trenched in the same formation, are directly proportional in size to the present streams, and the higher upland ridges never closely approach the cañon valleys. This is a rule which governs the product of a well balanced drainage system. It here indicates that none of the streams (with one exception—the Mississippi), in northwestern Illinois, differ materially in relative size from those which formed the basin valleys. The imaginary plain which may be drawn through the bottom of all these basin valleys is undoubtedly a basal plane of erosion. While it will show slight deformation, due to subsequent differential uplift of the district, it will have a level irrespective of the structure of the rocky strata. In fact, the evidence that this plain will not be merely an apparent baselevel, due to the coincidence in altitude of a great number of structural plains in all parts of the district, is stronger than for the peneplain character of the upper dissected plain, whose baseleveled condition is doubted by scarely any one.

The basin valleys do not seem to be represented in a very definite form north of Illinois and the same latitude in Iowa. The broad sandstone plain of central Wisconsin appears to bear a similar relation to the main Tertiary peneplain and the cañon valleys, as the basin valleys in Illinois. But the presence of the very resistant Baraboo quartzite ledges crossing the course of the stream which baseleveled the lowland plain northward from them has suggested to Chamberlin that to them chiefly is due its apparently baseleveled condition. The "Trenton terrace" at St. Paul and Minneapolis, also bears a relation to the Tertiary peneplain and the cañon valleys identical with that of the basin valleys in Illinois. But here it is impossible, with the present evidence at least, to demonstrate that it is not due solely to the structural inequalities of the formations excavated.

The cañon valleys of the upper Mississippi region. This very prominent topographical feature of the area under dis-

cussion, is already so well known that a few words in regard to it will suffice at the present time. Throughout the country within twenty miles on either side of the Mississippi river, from St. Paul to the Wapsipinicon and Green River basins in Iowa and Illinois, the streams flow in comparatively narrow, steep-sided valleys, which have a present depth between 100 and 600 feet. The rock bottom of these valleys is everywhere from 100 to 200 feet beneath the present stream level, indicating that the land was once more elevated than at present.

They are not narrow and deep enough to constitute true cañons as the term is applied in the southwest, but their form and mode of origin are such as to include them under the class of "cañon valleys." In age, they occupy the time interval between the completion of the Tertiary peneplain and the opening of the Kansan epoch of glaciation. The peneplain is probably identical in age with that in the southern Appalachian region, which is the product of the Tennesseean epoch of degradation as lately defined by McGee. This was followed, in the coastal plain and Mississippi embayment regions, by the Lafayette submergence and epoch of aggradation. As the same writer has indicated, this Lafayette subsidence of the territory now occupied by the southern states, must have been accompanied by a tilting and possible slight uplift of the central and upper Mississippi regions, to revive the senile streams and enable them to supply to the sea at their mouths, material which was rapidly gathered from the red residuary clay of the land surface. It is probable that the basin valleys of northwestern Illinois belong to this Lafayette period of increased stream action. The Lafayette submergence of the continental border was terminated by a marked uplift of the entire eastern portion of North America, and to this epoch belongs our cañon valleys. All that portion of the valleys of the upper Mississippi region, which lies beneath the level of the floor of the basin valleys, should be classed as Ozarkian in age, this name having lately been proposed for the epoch between the Lafayette and the Kansan.

The age and origin of the present Mississippi river. Above the city of Minneapolis, the Mississippi river flows in a shallow valley channeled beneath the surface of great drift plains,

but rarely reaches the indurated rock. This portion of its course is post-glacial in age. At St. Anthony falls, the stream plunges or did plunge before the arrival of civilization, over a ledge of Trenton limestone, and thence for eight miles flows through a narrow, steep-sided gorge, entirely post-glacial in age. At Fort Snelling, it enters the valley of the Minnesota river, and immediately makes a sharp bend toward the northeast. It flows thence past the city of St. Paul in a well defined cañon valley which averages 3,000 feet in width and 100 feet in depth. Its walls are precipitous bluffs of St. Peter sandstone capped by a 25-foot stratum of hard blue Trenton limestone. Their sharp cut outlines are due largely to glacial and perhaps post-glacial erosion. Just below or east of the city, the narrow cañon valley suddenly gives way to a much broader and older appearing cañon valley which has a trend toward the south-south-east. This latter valley averages two miles in width and has sides mantled and often deeply buried under drift. It is undoubtedly the old or pre-glacial valley of the Mississippi river. Almost as certainly is the narrow, new appearing cañon valley which passes St. Paul not the pre-glacial trough through which the ancient Mississippi held its way. It is in the direct line of continuation of the Minnesota river valley and may formerly have been occupied by that stream. Its great depth below the present river level (about 200 feet) seems to place it in the category of pre-glacial valleys, but its comparative narrowness, especially the short distance (about two and one-fourth miles) between the known areas where the soft Trenton shales are in considerable thickness on either side of it, somewhat negative a reference to it as the pre-glacial valley of the Minnesota river. It is possible that it may yet be shown to be inter-glacial in age.

Disregarding the much narrower valley which enters it from the west, the pre-glacial cañon valley of the Mississippi river, ends abruptly at the southeastern corner of St. Paul. The high upland area which trends north and south on its eastern side at some distance from its immediate border, continues without a change for many miles to the north passing to the east of lake Phalen. Although deeply covered with drift, it is undoubtedly based on an upland area of rock.

To the west of it, and in the direct line of continuation of the old Mississippi valley, there is a topographical depression which trends for many miles to the northwest. It is occupied in places by lakes, the most important of which is lake Phalen. This, in my opinion, will probably be found to be the ancient course of the Mississippi river. That it is the position of a pre-glacial valley is indicated by a deep well at the St. Paul Harvester Works, situated in the present topographical depression, which penetrated rock at 235 feet beneath the surface or 628 feet above the sea, which is 55 feet beneath the present low-water level of the Mississippi river at St. Paul. The lake Phalen depression is separated from the head of the Mississippi cañon valley by a moraine which is evidently based on a comparatively low surface, for it does not rise nearly as high as the drift to the east or west. As seen from the opposite side of the valley, its escarpment or bluff at the head of the old cañon valley shows such topography as is usually produced by the erosion of drift. In short, all the evidence favors this lake Phalen depression as the position of the pre-glacial continuation of the Mississippi cañon valley.

From the southeastern corner of St. Paul to Le Clare in Iowa, the Mississippi river is undoubtedly in a pre-glacial valley. But as we proceed southward along its course, we become more and more strongly impressed with the idea that it is relatively too large a stream for its valley. That is, that in comparison with the cañon valleys of tributary streams, the gorge is proportionally too small. In the vicinity of Dubuque we find some very definite evidence on this point and I will give it in some detail.

Standing on the high bluff in the city of Dubuque, we look beyond the great river to a remarkably even upland plain in southwestern Wisconsin and northwestern Illinois. It is the Tertiary peneplain and we stand upon its surface. Several miles above the city this dissected upland plain appears to approach almost to the very verge of the steep-walled cañon valley, producing bluffs over 250 feet in hight. Directly opposite to us, the bluff is but about 160 feet in hight while from its summit the land rises by a gradual slope another 100 feet to the remnant ridges of the Tertiary peneplain one mile

or more away from the river. In the northern part of Dubuque, several ridges of nearly even hight form a dissected plain or terrace at least 100 feet beneath the Tertiary peneplain. They, in conjunction with the 160-foot bluff on the east side of the valley, represent the basin valleys of northwestern Illinois. This basin valley, here not averaging over two miles in width, trends from northwest to southeast. It sends long narrow arms up the Little Maquoketa and its tributaries. The cañon valley of the Mississippi enters it on its northeastern side and passes obliquely across it at Dubuque touching its southwestern side, thus again producing a 250-foot bluff. Southward from Dubque this basin valley is plainly discernible as far as the topographical features of the land surface can be distinguished.

Now, the point to which I wish to chiefly attract attention is the comparative narrowness of this basin valley. It is carved entirely in the Galena limestone, a formation which here is substantially identical in every particular with its outcropping portions throughout northwestern Illinois. Remembering that the basin valleys in the Galena limestone are always proportional in size to the streams, and making allowance for a greater depth and therefore naturally less width of the valley at Dubuque than others with which it may be compared, we will conclude that a stream no larger than the Pecatonica river at Freeport was engaged in excavating it. Furthermore the distance between the edges of the dissected Tertiary peneplain on either side of the cañon valley, a few miles above Dubuque, is scarcely sufficient for the basin valley of a stream as large as the Pecatonica river. If now we pass down the river we shall find this basin.valley gradually increasing in width, especially where it crosses the Hudson River shales, but nowhere as large as the basin valley of a stream thrice as large as the Pecatonica river. Adopting a sufficient factor, of safety, to cover all the possible causes of error in making comparisons, I feel confident in making the following assertion. The present course of the Mississippi river between Dubuque and Le Claire, Iowa, was occupied, up to the close of the epoch during which the basin valleys were being eroded (Lafayette?) by no stream larger than the present Rock river between Rockford and its mouth.

Returning now again to Dubuque, we will look at the cañon valley. Including the buried portion, it has a depth of about 300 feet and a width at the city of about one mile, averaging one and one-half to two miles from here southward as long as it remains on the Galena terrane. Comparing with the cañon valleys of the Pecatonica and Rock rivers where they are trenched into Galena limestone it is seen to be somewhat larger than that of the former stream but decidedly less in width and slightly less in depth than that of the Rock river. Even adopting a larger factor of safety we are compelled to conclude that the cañon valley of the Mississippi, which undoubtedly may be included in the same system as those of its tributaries, was excavated mainly by a stream decidedly smaller than that which now occupies it. Therefore, the inference seems reasonable that the origin of the Mississippi river as a large stream flowing past Dubuque did not precede the close of the Ozarkian epoch. It is also evident that a divide must have existed across the present course, not many scores of miles above Dubuque. I have not the data for locating even approximately the situation of this divide, but I would suggest that local observers search for it somewhere between La Crosse and Prairie du Chien, particularly where the "military ridge" is traversed by the present river.

Northward from this supposed divide, the present cañon valley of the Mississippi must have been occupied by a stream flowing toward central Minnesota instead of away from it. Theoretically this is a strong probability for the following reason: Sometime in the later portion of the Cretaceous period the Minnesota depression was occupied by the sea. The drainage of the land on its eastern side must have been from the most distant interior parts directly to and into this sea. It is impossible that a southwardly flowing stream in the course of the present upper Mississippi could then have existed. Subsequently, when the sea retreated and the early Tertiary uplift occurred, the water level in the vicinity of the site of St. Paul, was not seriously interfered with. But an "uplift" was developed toward the southeast, reaching a maximum near Dubuque and thence northeastward into central Wisconsin. Had a southeastwardly flowing stream existed on the course of the Mississippi previous to the institution of the uplift, it

might have maintained its course by more rapid down-cutting of its channel than the crest of the "uplift" was elevated. But as such a stream did not exist in the Cretaceous period, it is not probable that it should have originated later, flowing from a flat lowlying plain, through deep valleys across an "uplift." On the contrary, the most natural direction of flowage in such a stream as that which originated the cañon valley of the Mississippi along the southeastern border of Minnesota, is northward. Slightly corroborative evidence of it is furnished by the fact that many of the streams on its western side, north of the "military ridge" enter it from the southwest, instead of the northwest as they should in a well balanced drainage system. There may, however, have been a different cause for this.

It has been shown that there is sufficient evidence of the comparative recency of the Mississippi river as a large stream flowing on the western border of the territory of northwestern Illinois, to warrant us in considering its origin as not earlier than a late portion of the Ozarkian epoch. This brings it so close to the Kansan epoch that it does not require a great stretch of the imagination to consider it as having resulted from the disturbance of other drainage systems by the accumulating northern ice. For instance, it is quite possible that the Kansan ice-sheet had advanced across the outlet of the supposed northwardly flowing ancestor of the upper Mississippi river, obstructing its flowage, and after the production of a great extra-glacial lake, turning the drainage of the entire region over the lowest point on the divide which intervened between it and the head waters of the southwardly flowing ancestor of the central Mississippi river, long before it glaciated the country south of the "driftless area."

The present bluffs of the Mississippi cañon valley have been eroded by the "larger Mississippi," and have an appearance of greater youth than those of its tributary cañon valleys. This is finely illustrated on the east side of the valley near Dubuque. The bluff of the great cañon is straight, and often precipitous, always rocky, and nearly free from timber. The bluffs of the small tributary valleys are timbered slopes, always steep, but rarely bare precipices. Southward from Dubuque, the cañon valley has been widened in places so as

to almost equal the width of the basin valley, nearly obliterating it. In Whiteside county, Illinois, the upland ridges which constitute the dissected Tertiary peneplain, extend to the verge of the great cañon valley, forming so-called "200-foot bluffs." The intervening basin valleys where they are transected by the Mississippi valley, form "100-foot bluffs." This indicates great widening of the cañon valley by a stream vastly larger than that which channeled the basin valley. Evidence of this class is abundant throughout the stream's course between Dubuque and Le Clare. Being quite familiar with the characteristics of the valleys eastward from the great river, I have never yet come upon its cañon valley without being impressed with its general appearance of greater youth than others of apparently the same system.

In concluding these remarks on the age of the "larger Mississippi" river, I wish to repeat, firstly, that I am certain that it cannot be earlier than the opening of the Ozarkian or post-Lafayette epoch of erosion; secondly, that there is evidence to indicate that it did not exist until near the end of the Ozarkian epoch; thirdly, that since the large or present Mississippi river began to flow in the cañon valley on the western border of northwestern Illinois, it has widened it somewhat, giving it the appearance of greater youth than others of the same system; fourthly, that the relation of this newly eroded valley to the Kansas drift below Savanna indicates that the "larger Mississippi" had come into existence before the Kansan glaciation of western Illinois and southeastern Iowa; and lastly, that, while the cause of the creation of the "larger Mississippi" may have been an uplift of the northern portion of the Mississippi basin, it is just as probable that it was due to obstruction of a northern drainage system by the accumulating Kansan ice.

EDITORIAL COMMENT.

Recent Estimates of Geological Time.

In an address June 3d at the annual meeting of the Victoria Institute, in London, Lord Kelvin estimated the age of the earth, since it was sufficiently cooled to become the abode

In short, these basin valleys in northwestern Illinois are everywhere present, and such prominent features of the topography, that the observant traveler can not fail to notice them. In the country southward from Jo Daviess and Stephenson counties, they occupy three-fourths of the surface. All those which are trenched in the same formation, are directly proportional in size to the present streams, and the higher upland ridges never closely approach the cañon valleys. This is a rule which governs the product of a well balanced drainage system. It here indicates that none of the streams (with one exception—the Mississippi), in northwestern Illinois, differ materially in relative size from those which formed the basin valleys. The imaginary plain which may be drawn through the bottom of all these basin valleys is undoubtedly a basal plane of erosion. While it will show slight deformation, due to subsequent differential uplift of the district, it will have a level irrespective of the structure of the rocky strata. In fact, the evidence that this plain will not be merely an apparent baselevel, due to the coincidence in altitude of a great number of structural plains in all parts of the district, is stronger than for the peneplain character of the upper dissected plain, whose baseleveled condition is doubted by scarely any one.

The basin valleys do not seem to be represented in a very definite form north of Illinois and the same latitude in Iowa. The broad sandstone plain of central Wisconsin appears to bear a similar relation to the main Tertiary peneplain and the cañon valleys, as the basin valleys in Illinois. But the presence of the very resistant Baraboo quartzite ledges crossing the course of the stream which baseleveled the lowland plain northward from them has suggested to Chamberlin that to them chiefly is due its apparently baseleveled condition. The "Trenton terrace" at St. Paul and Minneapolis, also bears a relation to the Tertiary peneplain and the cañon valleys identical with that of the basin valleys in Illinois. But here it is impossible, with the present evidence at least, to demonstrate that it is not due solely to the structural inequalities of the formations excavated.

The cañon valleys of the upper Mississippi region. This very prominent topographical feature of the area under dis-

assigned by Mr. Taylor, under his modification of Dr. James Croll's astronomic theory. A better explanation, as the present writer believes and endeavored to show in the last June number of this magazine. is through the effect of englacial and superglacial drift, as was first suggested by Russell and Woodworth, causing much marginal drift deposition at recurring stages of the glacial recession, even without any secular climatic changes. W. U.

THE STATE GEOLOGIST OF MISSOURI.

Referring to our note in the September GEOLOGIST on the "Missouri Geological Survey," we append herewith further evidence of the magnitude of the revolution effected by the managing board. We have to apologize to the geologists of the country for disturbing their sensibilities further with this subject, but wish to give them the best of the case on both sides. N. H. W.

JEFFERSON CITY, MO., Sept. 16, 1897.

Editor "American Geologist,"

Minneapolis, Minnesota.

DEAR SIR:—In your September issue, under the head of editorial comment, appears a characteristic wail. Having just now no other available defense against such cowardly thrusts, I enclose copy of my letter to Mr. Chamberlain of the "Journal of Geology."

You and he have alike demonstrated how recklessly an "oracle" of human duplicity can prostitute the function of a so-called scientific journal. While your article is not quite so rabid, having been inspired by a different "reliable informer," it is quite as cowardly as his and for that reason the enclosed letter will not be a total misfit for you.

It is my function to unfold and display the Geology of Missouri so vividly that the tax-payers will be the beneficiaries. Notwithstanding your slanderous insinuations, a great many good people seem to think that I am eminently qualified for that work. Anticipating that your final resort will be that of the knave whose mouth went off before his brain acted, I am ready to forgive, but I shall always think that if you had had one thin streak of true manhood in you, you would have waited until my first report was published and then have judged of my ability as compared with that of my predecessors.

On the other hand, truth is always logical and simple when you have found it. Being not entirely without personal ambition, I am thankful to all who helped me into this position and I trust that in the end I shall have reason to feel thankful even to you for a persistent but impotent effort to throttle truth with your partisan wail.

Respectfully,

[*Enclosure.*] JNO. A. GALLAHER, *State Geologist.*

JEFFERSON CITY, MO., Sept. 15, 1897.

MR. CHAMBERLAIN, *Editor "Journal of Geology,"*
Chicago, Illinois.

DEAR SIR:—A malicious article in your issue for July and August under the head of editorials, has recently fallen under my eye. I sent the paper to a friend without noting your initials or street, but trust this will reach you.

Primarily, truth is the only objective of science. Since you have ignored truth entirely in your one-sided editorial, just as your client has ignored fundamental facts and definite knowledge in his so-called Geological Survey of Missouri, I will say to you that notwithstanding your scurillous attack I am still here and ready to cope with either of you on any scientific question. As a partisan, a slanderer or a liar, I cannot hope to compete with you successfully. But on scientific questions, I am always ready for you.

While your client is on record, in his so-called Geological Reports of Iowa and Missouri, and you are on record as his willing champion, the only favor I ask is that you persevere until you get all of your kind committed. Should you escape the criminal prosecution you so richly deserve for malicious libel and coyotes will count, I shall hope to get before the public, ere long, with scalps enough to make myself solid with the tax-payers of Missouri.

The present broad-minded Board gave your friend a fair opportunity to get out of Missouri without exposing his incompetency. He failed to utilize the opportunity and the office had to be declared vacant. He left his tracks, not only in his reports, but in Kansas City, St. Joseph and finally in your contemptible editorial. Now if it should transpire, despite your partisan effort, that Missouri has eliminated an incubus, a parasite or a "scientific" fraud, it will not be the first instance wherein a supercilious parasite has unwittingly dug his own grave. It remains for an unbiased public to determine whether or not you and he have earned that logical fate.

I will now remind you that "every dog has his day." This is my day and the time is not far distant when your client will wish he had carried his tracks along with him. That you and he have run up against the wrong man, is only a question of time. You can make the most of your opportunity and I will pursue the even tenor of my way.

I am, Sir,

JNO. A. GALLAHER, *State Geologist.*

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Iowa Geological Survey, Volume VI: Report on Lead, Zinc, Artesian Wells, etc. SAMUEL CALVIN, State Geologist. Pages 487, with 28 plates and 57 figures in the text. Des Moines, 1897. This volume comprises four papers, as follows: Lead and Zinc Deposits of Iowa, in 58 pages, by A. G. LEONARD; The Sioux Quartzite and certain Associated

Rocks, in 56 pages, by SAMUEL WALKER BEYER: Artesian Wells of Iowa, in 316 pages, by WILLIAM HARMON NORTON; and Relations of the Wisconsin and Kansan Drift Sheets in Central Iowa, and Related Phenomena, in 48 pages, by H. FOSTER BAIN.

Prof. Leonard describes the mines of Dubuque, Clayton, and Allamakee counties, in northeastern Iowa, on the west border of the Upper Mississippi lead and zinc district. The ores are galena, smithsonite, and sphalerite, occuring in crevices of the Galena limestone. The ore concentration is attributed to lateral secretion from the limestone by infiltrating surface waters; and the original source of the ores, as Whitney long ago suggested, is held to have been the ancient sea, at whose bottom the limestone was formed, the sea itself having received its metallic salts from the decay of the Archean rocks.

The Sioux quartzite, described by Dr. Beyer, extends only one or two miles into the northwest corner of Iowa, so far as it is seen in outcrops. The localities here chiefly described are between six and fifteen miles farther north, in Minnehaha county, South Dakota, where the quartzite is succeeded above by thinly bedded quartz-slates, which vary in texture from fine-grained homogeneous "pipestone" to argillaceous quartzite. An extensive mass of diabase, which is thought to have been intruded between bedding planes of the slates, is exposed along a distance of about a mile in the valley of Split Rock creek; and the author presents the results of his study of its mineral composition and alteration products.

The artesian field of Iowa is shown by Prof. Norton to be a part of a much larger basin which reaches southward into Missouri and eastward into Illinois. Its main area of intake from rains is on the north, where the St. Croix and St. Peter sandstones outcrop in the southern parts of Wisconsin and Minnesota. The altitudes to which the artesian flows rise have a somewhat regular gradient from 1200 feet above the sea in northwestern Iowa to 700 feet in its southeastern part. Records of the Iowa wells, and details of their relations to the stratigraphy of the region, are followed by a discussion of the chemistry of artesian waters, notes of their use as a public supply, and a bibliography for the state. This is a very thorough and admirable memoir, which will be of great value as a guide to the further development of the artesian water supply.

In the last paper of the volume Mr. Bain gives results of his studies of the glacial drift in central Iowa, including the southern end of the Minnesota and Iowa lobe of the ice-sheet in its Wisconsin or moraine-forming stage. A synopsis of the successive stages of the Glacial period, as recognized in Iowa by Prof. Calvin, appeared in the last April number of this magazine (pages 270-272), and Mr. Bain here discusses the ratios of these stages. He agrees substantially with the ratios published by Prof. Chamberlin a year ago in the Journal of Geology (vol. IV, pp. 872-876). Prof. N. H. Winchell's estimate of the Postglacial period as 7,800 years, based on the recession of St. Anthony's falls, is accepted; but for the previous time of retreat of the ice-sheet from Des Moines to Minneapolis an undetermined addition is required. This duration since the maximum extension of the Wisconsin ice-sheet is thought to

be only a tenth or fifteenth part of the time since the more extensive Kansan glaciation, which itself had an unestimated duration and was preceded by the still less known Aftonian and Albertan stages. W. U.

Geology of Johnson County. By SAMUEL CALVIN. From Iowa Geological Survey, vol. VII (Annual Report for 1897), pp. 33-116, with two maps, two plates, and ten figures in the text. Silurian, Devonian, and Carboniferous formations, with overlying Kansan and Iowan drift and loess, form this county, lying in the southeast part of Iowa. Its largest town, Iowa City, was the first capital of Iowa, and is the seat of the state university.

At the State Quarry, worked for the new capitol at Des Moines, it is found probable that the heavy-bedded limestone of the quarry is of Upper Devonian age, being of small area and deposited in a deeply eroded hollow of the adjoining Cedar Valley limestone, of Middle Devonian age. Both formations are nearly horizontal, but between their times of deposition the sea bed here appears to have been temporarily elevated to be dry land channelled by streams.

The Kansan till was much eroded, and became superficially oxidized, while its carbonate of lime near the surface was removed by the growth of plants and the leaching effect of percolating water, and its granite boulders suffered decay, before the much later Iowan stage of re-advance of the ice-sheet. The Iowan till has undergone none of these changes, showing that its age is far more recent. Of this later till Prof. Calvin writes: "Oxidation is not more marked at the surface than in the deeper parts of the deposit. Calcareous matter is about as abundant at the grass roots as it is ten feet lower down. The bowlders are sound and hard, showing no signs of decay." The lobate border of the Iowan drift is marked by moraine hills which rise 40 to 80 feet above the general level of the contiguous plain. Southward the loess, derived from the melting Iowan ice-sheet, overspreads the Kansan drift. It also occurs in ridges, called by McGee paha, within the area of the Iowan till, these being of similar origin as the sand and gravel eskers of other regions.

The drift deposits of Johnson county vary greatly in depth, and their maximum exceeds 250 feet. The very irregular surface which had been produced by a period of erosion immediately preceding the earliest glaciation was changed by the deposition of the drift, so that it is now mostly a moderately undulating or nearly level expanse, only rarely broken by projecting preglacial hilltops.

Following the geological report, Prof. T. H. Macbride gives a list of the forest trees of the county; and Dr. C. R. Eastman contributes an important preliminary report of eight pages, with a plate, on the Devonian lung-fishes whose teeth occur in great abundance in a bed of the State Quarry. W. U.

A Treatise on Rocks, Rock-weathering and Soils. By GEORGE. P. MERRILL. (8vo, xx and 411 pp., 25 pls. and 42 figs.; New York, The Macmillan Co., 1897. Price $4.00.) The first two parts of the book comprising 172 pages, are devoted to a discussion of the rock-forming minerals and of rocks, including their classification and general characteristics. While the author states that this work is to be considered in no

sense a petrology, the pages devoted to rocks being regarded as a necessary introduction to that part of the book which deals with rock-weathering, still it seems that much more space is given to the discussion of the origin, structure and classfication of rocks than is essential for the purposes of a correct understanding of the processes and results of weathering. At the same time this petrological part of the work will be of assistance to many students who desire a brief introduction to the study of rocks and who cannot use and appreciate the larger treatises of Rosenbusch and Zirkel.

Part III begins with a consideration of the principles involved in rock-weathering and this is followed by a discussion of special cases. Here the chemical composition of a number of fresh and partially or completely weathered rocks is given, the different analyses of each rock being made from exposures which show the fresh and decayed rock immediately associated. Many of the analyses were made by the author, or under his direction, from material collected by himself with the special object of the book in mind. The value of these analyses for the work in hand is thus apparent. It becomes a matter of some importance in studying these analyses to determine the percentages of the various parts of the rocks lost by solution in the process of weathering. In order to attain a basis for the calculations a certain chemical component of the rock is assumed to have remained undissolved in the weathering process. The component thus taken is usually alumina (Al_2O_3), but in some cases iron sesquioxide (Fe_2O_3) is found to remain practically undissolved. In limestones the silica is thought to remain constant. With such a basis to start on the relative amounts of the various components lost is readily calculated.

Part IV is devoted to transportation and redeposition of rock débris, and part V to a discussion of the *regolith*, a term applied to the earth's mantle of unconsolidated material. Here is included a discussion, with many analyses, of the chemical nature and the various properties of different kinds of soils. U. S. G.

CORRESPONDENCE.

ORIGIN OF THE LOESS. In the September number of the AMERICAN GEOLOGIST I find it reported that in my paper on the origin of the loess, presented at the meeting of the Geol. Soc. of America in Detroit, I "took the wide view of the loess, including in it all forms and conditions of this material—that in the river valleys and that at all altitudes—and maintained that it was all due to wind-action and was an accumulation of dust carried in the atmosphere." In the paper referred to, the following statement was made: "The waters of these rivers (the larger drainage channels of the loess region) may have added a part of the material (of the loess) in some places along their courses. This is indicated by occasional stratified phases of the loess in such places."

I also find it stated that I should have "argued that its (the loess') lack of assortment was conclusive proof that it was not of aqueous origin." What I said with regard to this was the following: "An aqueous

deposit, spread over hundreds of miles of a broken topography and reaching a thickness of a hundred feet, could not very well be as uniform in its mechanical composition as the loess is. It would more frequently contain coarser materials. In particular it seems improbable that a water deposit, as fine as the loess, should be without thin seams of fine silt, such as are generally to be observed in aqueous sediments. These are more or less conspicuously laminated. In a (fine) wind sediment on the other hand such a sorting and lamination is impossible, owing to the smallness of each sorted load, to the less constancy of the depositing current, and to disturbing agencies which are at work thoroughly mingling successive deposits on the surface of the land."

I appreciate the difficulties attending the reporting of all the papers presented at such a meeting, especially when the reporter merely hears the papers read once and has no opportunity himself to see the manuscripts. The above correction is cheerfully made.

Respectfully, J. A. UDDEN.

Rock Island, Ill., Sept. 17th, 1897.

TORONTO MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. The presidential address of Dr. G. M. Dawson to the section of geology dealt with the recent progress in our knowledge of the crystalline rocks of Canada. He referred to the establishment of the doctrine that the greater part of the Huronian beds were of volcanic origin. In his view the Laurentian fundamental gneiss existed originally as the floor on which the Huronian was deposited. The Grenville series has been shown by analysis to consist of the same material in ultimate composition as the Paleozoic argillites and is probably metamorphic, while the anorthosite group is found to consist essentially of intrusive rock, often folded, later in date than the Grenville series, but probably pre-Paleozoic.

The same structure prevails in New Brunswick and there the fundamental gneiss is in contact with a series of limestones, quartzites, and gneissic rocks, precisely like those of the Grenville series. All these are unconformable beneath fossiliferous beds, regarded by Matthew as older than Cambrian. The same is true of the Cordilleran region.

The speaker then passed on to the consideration of the base of the Cambrian system and the range of the term "Paleozoic." The former is at present arbitrary and paleontological, and the latter is now extended by some to include all fossiliferous strata downward.

In both these respects he expressed doubts regarding the possibility of maintaining this practice as the field grew wider. "On the Atlantic side the Olenellus zone is a fairly well marked base for the Cambrian; on that of the Pacific it is found naturally to succeed a great consecutive and conformable series of sediment whose more ancient fauna is only now beginning to be known."

Dr. H. M. Ami discussed the little known formations and faunas of Ordovician age in New Brunswick and Nova Scotia and after attempting the subdision of these formations by their faunas, he essayed their paralellism with their taxonomic equivalents in Europe. The Devonian and Carboniferous systems were treated in like manner.

Dr. Ami also read a paper by Dr. G. F. Matthew on the distribution of certain species in the Cambrian rocks. The author stated that *Bathyuriscus*, a Middle Cambrian genus in Montana and Nevada occurred with *Olenellus* in eastern North America and is very closely allied to *Dolichometopus* of the upper *Paradoxides* bed of Sweden and eastern Canada. With it occurs *Dorypyge*. a Middle Cambrian form in Montana., but also found in the *Olenellus* beds of eastern North America. *Microdiscus* ranges from the *Olenellus* fauna to the upper *Paradoxides* bed. *Agnostus* in the two forms *lævigati* and *brevifrontes* also ranges from the *Olenellus* to the upper *Paradoxides* horizon.

"It is difficult," said Dr. Matthew "to understand how *Olenellus* can be at the base of the Cambrian and yet be found in the company of so many forms of the Middle Cambrian fauna."

Dr. Ami also read a paper by Mgr. Laflamme of the Laval university on the displacement of the river St. Anne in Quebec by the great landslide of April, 1894.

Prince Krapotkine presented a paper on the "Asar of Finland," written he said when he was confined in a St. Petersburgh prison in 1871 and 1876 and left behind him when he escaped. He only received it recently through the intervention of the Russian Geographical Society.

In the absence of its author the paper by Dr. Chalmers on the preglacial decay of rocks in eastern Canada, was read by title. We understand that its purport was to point out instances in which weathered rocks of various dates are buried under boulder clay and so preserved.

Mr. Coleman discussed the interglacial beds of the Don valley and Scarborough Hights. In the former section is seen a lowest till lying on Ordovician shale (Hudson River). Then follow eighteen feet of sand and clay with mussel and other shells, leaves and pieces of wood. Some of the former are of species now found farther south. Above this is a stratified clay and sand from which have been obtained a caribou horn and some remains of insects and plants belonging to a colder climate than the present. This is best seen at Scarborough Hights where it rises 148 feet above the water.

These beds were deeply eroded before the next till was laid down upon them and above this follows another series of fossiliferous interglacial beds to a hight of 240 feet and over these is a third till.

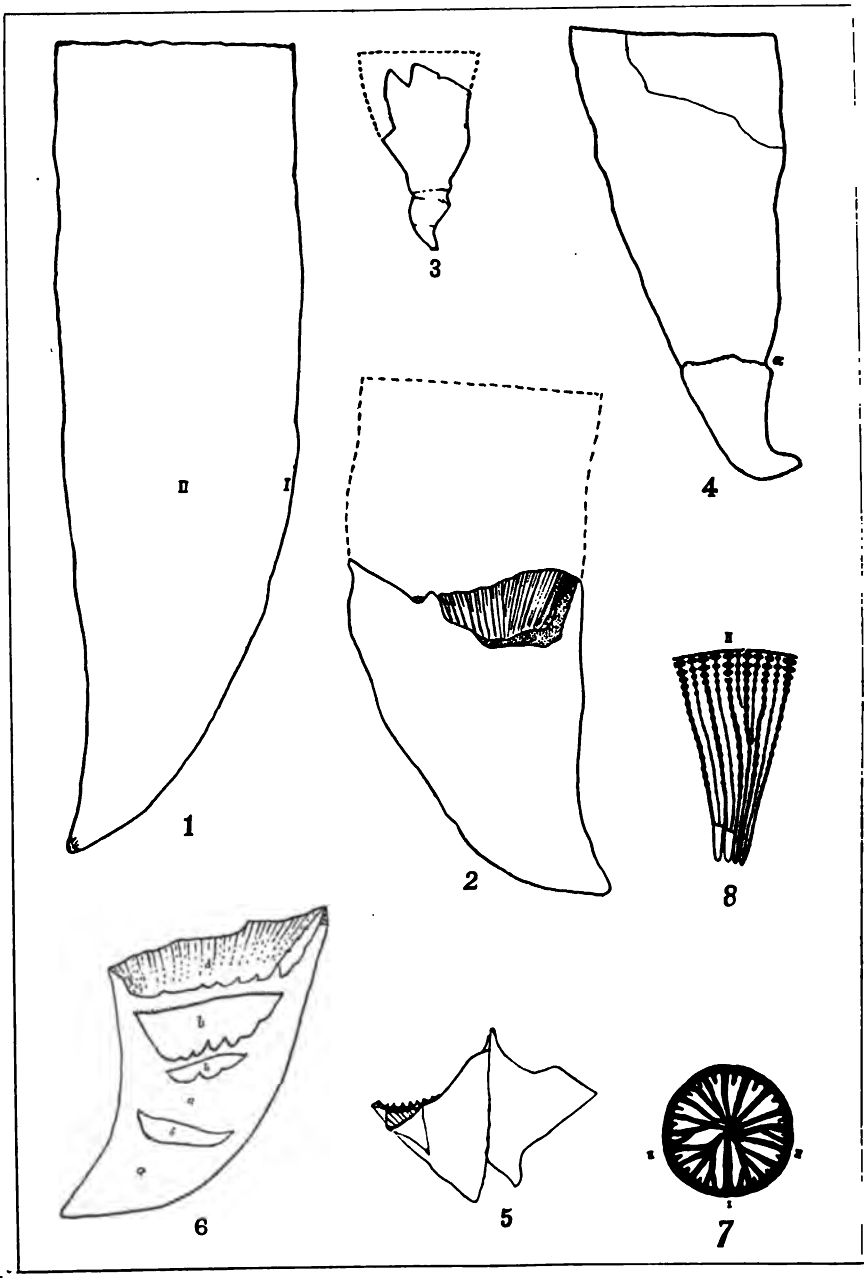
During the deposition of the middle and upper till the water stood from 260 to 300 feet above the present level of lake Ontario.

Mr. Bayley Willis spoke on the drift of Puget sound. On the slopes of the Cascade range drift deposits occur, he said, up to 1700 feet above the sea. The materials are largely granite but numerous erratics of Tertiary volcanic rocks indicate Mt. Tacoma as their place of origin.

Prof. T. C. Chamberlin discussed at considerable length several hypotheses bearing on climatic change, atmospheric conditions, and also the succession of ice-sheets in the Pleistocene.

Mr. H. B. Woodward spoke on the English chalky boulder-clay and Dr. Spencer on the continental elevation of the glacial era.

Papers were also presented by Prof. C. H. Hitchcock on the southern lobe of the Laurentian ice-sheet, and Prof. Shaler on the origin of drumlins.



STREPTELASMA PROFUNDUM.

THE

AMERICAN GEOLOGIST.

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ON STREPTELASMA PROFUNDUM (Owen) S. CORNICULUM Hall.

By F. W. SARDESON, University of Minnesota.

(Plates XVI and XVII.)

Twelve species of the genus *Streptelasma* have been described in America, from the Trenton and Hudson stages and in addition three species from the Hudson stage, which have been referred to the genus *Zaphrentis*. It is evident, however, upon investigation of several of these species, that they are synonyms only. There is apparently but one true species among the fifteen. I say apparently because I have not sufficiently authentic specimens of some of them to enable me to prove beyond doubt that only one true species is represented among the fifteen described as distinct. My collection contains several at least of the proposed species and without exception the ascribed distinctions between them, when studied, prove to be imaginary or not valid. The one species, *S. profundum* (Owen), which is known currently as *S. corniculum* Hall, when fully investigated shows all the characters which have been regarded as the distinctive characters of any one of the other fourteen supposed species, and there remains no good reason for assuming that more than one species is represented among them. If more than one is represented, it is too poorly described for recognition at this time and it is not evident in any of the specimens in my possession. Even two more species com-

posing the genus *Palæophyllum* demand admission to this long list of synonyms, since they are evidently based upon mistaken distinctions.

The little known *Streptelasma expansum* Hall is technically the type of the genus, but *S. corniculum* Hall as described by Edwards and Haime has been virtually the type species, and both of them are not yet distinguished from an older named species *S. profundum* (Owen). With very little doubt they are synonyms and *S. profundum* would therefore be the name of the type species.

Since first described, *S. expansum* Hall has remained a nearly unknown species. There has likewise always been doubt as to the true nature of the species *S. corniculum* Hall. No one could have recognized *S. profundum* (Owen) had there been an associated species. *S. corniculum* as described by Edwards and Haime, by Kunth and by Nicholson was the *S. rusticum* Billings, and not *S. corniculum* Hall. Not improbably the meagre descriptions and imperfect knowledge of these corals is all that has kept them from being recognized from the beginning as synonyms. The same cause has evidently permitted the coinage recently of even more of these species.

James Hall in 1847 described several species, viz.: *Streptelasma profundum* (Owen) Hall, *S. corniculum* Hall, *S. crassum* Hall, *S. multilamellosum* Hall, *S. parvulum* Hall, and *S. expansum* Hall, but Edwards and Haime (1851) in their great monograph recognized only *S. corniculum* and reduced *S. crassum*, *S. multilamellosum* and *S. parvulum* to the rank of synonyms. *Streptelasma expansum* Hall and *S. profundum* Hall they reported as doubtful. Billings (1857) on the contrary aimed to recognize all the above named and later made more of them, *S. rusticum* (Bill.) in 1858, and *S. apertum* (Bill.) and *S. angulatum* (Bill.) in 1862, besides *Palæophyllum rugosum* Bill. in 1858.

Nicholson (1875-89) has followed the example of the great authors, Edwards and Haime, except that he described *Palæophyllum divaricans* Nich., 1875. Recently E. O. Ulrich (1893) has made two more species, *S. parasiticum* Ulrich, and *S. breve* Ulrich. Winchell and Schuchert distinguish *S. profundum*, *S. corniculum* and *S. rusticum* besides admitting Ul-

rich's species. More recently Whiteaves has described *S. robustum* (1897).

Zaphrentis canadensis Billings (1862), *Z. affinis* Bill. and *Z. bellistriata* Bill. (1865) are especially noteworthy species since Eastman in his translation of Zittel substitutes the name *Z. canadensis* Bill. for *S. corniculum* Hall, without however reducing the genus *Streptelasma* to a synonym for *Zaphrentis* which, if his identification is true as it evidently is, must follow. Rominger has already shown that the two genera are not clearly separable.* James Hall retains it as a subgenus of *Zaphrentis*.†

From investigation it appears that some of the most important characters as well as unimportant ones that may be seen in *S. profundum*, have been misunderstood or overlooked and an account of my own observations is therefore presented here in order to re-affirm the facts or add others to the knowledge of these corals.

STREPTELASMA PROFUNDUM Owen sp.

Cyathophyllum profundum Owen (1844) Geological Exploration of Iowa, Wisconsin and Illinois, pl. 16, f. 5.

"Lower lead-bearing beds" i. e. Beloit formation, or Black River.

Streptelasma expansa Hall (1847) Pal. New York, vol. 1, p. 17, pl. 4, f. 6a-b. Chazy formation.

Streptelasma profunda Hall (1847) Pal. New York, vol. 1, p. 49, pl. 12, f. 4a-d.

Streptelasma cornicula Hall (1847) Pal. New York, vol. 1, p. 60, pl. 25, f. 1a-c. Trenton limestone.

Streptelasma crassa Hall (1847) Pal. New York, vol. 1, p. 70, pl. 25 f. 2a-c.

Streptelasma multilamellosa Hall (1847) Pal. New York, vol. 1, p. 70, pl. 25, f. 3a-c.

Streptelasma parvula Hall (1847) Pal. New York, vol. 1, p. 71, pl. 25, f. 4a-c. Trenton limestone.

Streptelasma corniculum Edwards and Haime (1851) Polypiers fossiles p. 398, pl. 7, f. 4.

Streptelasma cornicula Billings (1857) Canadian Nat. and Geol., vol. 1, p. 122, f. 3-4. Trenton limestone.

Streptelasma profunda Billings (1857) Canadian Nat. and Geol. vol. 1, p. 123, f. 7, 8. Black River to Trenton formation.

Petraia rustica Billings (1858) Rep. Progress Geol. Sur. Canada for 1857, p. 168. Hudson River group.

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*Foss. Corals, p. 140.

†Pal. N. York, vol. 6, p. xi.

Palæophyllum rugosum Billings (1858) Rep. Progress Geol. Sur. Canada for 1857, p. 168. Trenton limestone.

Petraia aperta Billings (1862) Palæozoic Foss., vol. 1, p. 102, f. 89, Black River formation.

Petraia angulata Billings (1862) Palæozoic Foss., vol. 1, p. 103, f. 90. Hudson River group.

Petraia canadensis Billings (1863) Geol. Canada, p. 208, f. 205.

Zaphrentis canadensis Billings (1862) Palæozoic Foss., vol. 1, p. 105, f. 93. Hudson River group.

Petraia cornicula Billings (1863) Geol. Canada, p. 156, f. 118.

Zaphrentis affinis Billings (1865) Canadian Nat. and Geol., vol. 2, p. 430. Hudson River group.

Zayhrentis bellistriata Billings (1865) Canadian Nat. and Geol., vol. 2, p. 430. Hudson River group.

Streptelasma corniculum Nicholson (1875) Pal. Ontario, p. 12. 26.

Streptelasma corniculum Nicholson (1875) Pal. Ohio, vol. 2, p. 218. Cincinnati group.

Palæophyllum divaricans Nicholson (1875) Pal. Ohio, vol. 2, p. 220, pl. 2?, f. 10, 10a, 10b. Cincinnati group.

Streptelasma corniculum Rominger (1876) Fossil Corals Michigan, p. 142, pl. 51, f. 1, 2. Hudson River group.

Streptelasma corniculum Hall (1882) 11th Rep. Geol. Sur. Indiana, p. 376, pl. 51, f. 2-4. Cincinnati group.

Streptelasma corniculum Nicholson (1889) Manuel Pal., vol. 1, p. 247, f. 127B; p. 278, 279, f. 156 AB; p. 280, f. 157; p. 297, f. 178. Cincinnati group.

Streptelasma corniculum Keyes (1894) Missouri Geol. Sur. Rep. vol. 4, p. 117, pl. 13, f. 9. Trenton.

Streptelasma corniculum Zittel (1892) Grundzuege d. Palæontol. f. 111, p. 71, (after Nicholson).

Zaphrentis canadensis Zittel-Eastman (1897) Textbook of Palæontology, f. 111, p. 75, (same figures as last).

Streptelasma profundum Winchell and Schuchert (1893) Final Rep. Geol. Nat. Hist. Sur. Minnesota, vol. 3, p. 88, pl. G, f. 17-19. Black River and Birdseye.

Streptelasma parasiticum Ulrich (1893) Final Rep. Geol. Nat. Hist. Sur. Minnesota, vol. 3, p. 89, f. 6. Trenton shales.

Streptelasma corniculum Winchell and Schuchert (1893) Final Rep. Geol. Nat. Hist. Sur. Minnesota, vol. 3, p. 92, f. 7. Galena shales (Trenton).

Streptelesma breve Ulrich (1893) Final Rep. Geol. Nat. Hist. Sur. Minnesota, vol. 3, p. 92, f. 7. Galena shales.

Streptelasma rusticum Winchell and Schuchert (1893) Final Rep. Geol. Nat. Hist. Sur. Minnesota, p. 93, pl. G. f. 22, 23. Hudson River group.

Streptelasma robustum Whiteaves (1896) Canadian Record Sci., vol. 6, p. 391; (1897) Palæozoic Foss. vol. 3, p. 153, pl. 18, f. 1.

The first good description of the species is that by Edwards and Haime. Their specimens were from the upper part of the Cincinnati stage (Hudson stage) of Ohio and therefore the largest of the species—the same as Billings called *S. rusticum*. They are described as long conical, gently curved and partly attached by the apex. The beginning is a small point, from which the single cell or cup expands, curving gently, though most strongly during the first growth. The wall is marked by fine lines of growth. The septa are about 130 in number, sublamellar, alternatingly a little unequal, generally straight, and laterally striated. One dorsal line and two lateral lines are marked by the obliquity of the neighboring septa to them and these coincide with the primary septa. The septal fosette is small and lies on the convex side.

Billings (op. cit. p. 123) says that the "growth of these corals appears to have been as follows: At first they consist of a mere point attached to the rock, when the cup commenced to form there were only four partitions or lamellæ, as it increased others were added, three of the original ones continuing to grow and the fourth being undeveloped." The fourth one is developed however, though it is not marked off by the obliquity of other lamellæ, which has been proved by Kunth, who has described extensive observations on the Tetracoralla. The development of the septa as described by Kunth will be considered in detail further on.

A comparison of the geologically older with the younger representatives of the species—for example the specimens from the Beloit formation of Wisconsin with others from Richmond, Indiana—brings into contrast the average smaller size of the former specimens, but the difference is one which is indicative of a longevity of the latter as compared to the former, and not of any varietal difference. Both developed alike except that the latter grew longer and evidently lived longer. The corallum begins as a mere point, rapidly expands into a conical cup, increasing in diameter to a certain stage, after which it continues in length almost without increase or even with diminishing diameter. The rapidly expanding portion is, as Edwards and Haime said, the more curved, and it represents the period of increasing numbers of septa. Except in the later representatives, those of the Hudson period, the little curved,

ceived by this coral. *Palæophyllum rugosum* Billings, the type species, I have not investigated, but the author himself says: "This genus only differs from *Petraia* or *Streptelasma* by forming long fasciculate or aggregate masses, instead of being simple," (loc cit.). Even if truly observed would that one character be necessarily of specific or generic importance? I have not observed true budding in any of my specimens of *S. profundum*, much less true fission.

Distortion due to fracture of the corallum and later mending of it is not rarely observable in specimens from all horizons, (see fig. 3-4, pl. XVI), and if some individuals were wounded and recovered, others probably did not recover. Herein may be an explanation for the difference in average size between those from different horizons and localities since predaceous enemies, possibly *Asaphus gigas*, or again disturbances by water currents, and perhaps several such causes determined together their average size, and this in different times differently. There were certainly some causes or conditions in their surroundings, affecting probably the food supply to which may be ascribed certain constriction and expansion rings with which many examples are marked. Even the relative acuteness of the apical angle may be attributed to relative poverty of food supply. The curvature often changes in degree at some constrictions or by several of them. (See fig. 3, pl. XVI.)

The wall which is without visible epitheca is marked on the exterior by fine transverse rings and by longitudinal furrows, that coincide with the position of the septa as well known. Nicholson says in his Manual of Palæontology, p. 297, "A true theca does not seem to be present but the septa become much thickened towards their outer edges, being fused with one another by their lateral margins for a considerable distance, and thus giving rise to a dense false wall." But the original figures accompanying it as well as the description itself are evidence that specimens from which the theca has been etched away are being described. If the figured section (op. cit. fig. 127B) represented the external wall it would by its structure prove the cell margin to be vertically notched. But growth rings when preserved show that the margin was not vertically notched. The margin of the cell is perhaps never preserved but it was evidently the outer edge of the theca and was very

acute. The septa, developing from the inner side below the margin, were mere inward projections of the theca at first. The septa extended upward nearly but not quite to the growing margin of the cell. One sees that the exact position of the base of each septum is marked in most cases by an exterior longitudinal furrow in the theca and this proves seemingly that nearly always the point of the septum proper was preceded by an inflection of the calycle margin, corresponding to the later position of and continuous with the septum. The beginning of the septum proper is not an inflection but a thickening of the theca and where septa have begun to develop the wall is thence differentiated into septa and interseptal wall (fig. 1, pl. XVII). Evidently the septa grew rapidly towards the axis of the polypite or, in other words, in a direction perpendicular to the direction of growth of the calycle margin. Their growth in thickness was many times slower. Like the theca which grew more rapidly at the margin upwards than in thickness, so each septum grew rapidly at the margin but slowly in thickness. The bases of the septa are seen in cross sections of the thickened wall to be fixed wedge-like into the theca (figs. 1 and 2, pl. XVII). There is no fine division between theca and septum but a quick transition from darker to lighter colored deposit as seen in thin sections. The theca is the darker and shows chiefly the concentric striation of the organic constituent. The septa show the radiating constituent of the mineral constituent, but Nicholson (op. cit.) figures what would be the organic striation in these too, probably by mistake.

The theca grows, of course, only on one side, i. e. inwards. while the septa thicken on both sides, and, since the septa are not far apart, they coalesce as a rule laterally not far from their bases, excluding the theca so that it fills only the space between the septa before they coalesce. This takes place about at the ends of the minor sized septa. A sharp demarcation remains between the septa when they are in contact, because the calcareous prisms in one septum meet those of the other obliquely. Open spaces intervene under certain conditions after and before the septa have once coalesced. A median demarcation within any septum is very rarely observed, but the median portion or primary layer is regularly more transparent in sections than the later deposited thickening upon it.

Dr. Ami also read a paper by Dr. G. F. Matthew on the distribution of certain species in the Cambrian rocks. The author stated that *Bathyuriscus*, a Middle Cambrian genus in Montana and Nevada occurred with *Olenellus* in eastern North America and is very closely allied to *Dolichometopus* of the upper *Paradoxides* bed of Sweden and eastern Canada. With it occurs *Dorypyge*, a Middle Cambrian form in Montana., but also found in the *Olenellus* beds of eastern North America. *Microdiscus* ranges from the *Olenellus* fauna to the upper *Paradoxides* bed. *Agnostus* in the two forms *lævigati* and *brevifrontes* also ranges from the *Olenellus* to the upper *Paradoxides* horizon.

"It is difficult," said Dr. Matthew "to understand how *Olenellus* can be at the base of the Cambrian and yet be found in the company of so many forms of the Middle Cambrian fauna."

Dr. Ami also read a paper by Mgr. Laflamme of the Laval university on the displacement of the river St. Anne in Quebec by the great landslide of April, 1894.

Prince Krapotkine presented a paper on the "Asar of Finland," written he said when he was confined in a St. Petersburgh prison in 1871 and 1876 and left behind him when he escaped. He only received it recently through the intervention of the Russian Geographical Society.

In the absence of its author the paper by Dr. Chalmers on the preglacial decay of rocks in eastern Canada, was read by title. We understand that its purport was to point out instances in which weathered rocks of various dates are buried under boulder clay and so preserved.

Mr. Coleman discussed the interglacial beds of the Don valley and Scarborough Hights. In the former section is seen a lowest till lying on Ordovician shale (Hudson River). Then follow eighteen feet of sand and clay with mussel and other shells, leaves and pieces of wood. Some of the former are of species now found farther south. Above this is a stratified clay and sand from which have been obtained a caribou horn and some remains of insects and plants belonging to a colder climate than the present. This is best seen at Scarborough Hights where it rises 148 feet above the water.

These beds were deeply eroded before the next till was laid down upon them and above this follows another series of fossiliferous interglacial beds to a hight of 240 feet and over these is a third till.

During the deposition of the middle and upper till the water stood from 260 to 300 feet above the present level of lake Ontario.

Mr. Bayley Willis spoke on the drift of Puget sound. On the slopes of the Cascade range drift deposits occur, he said, up to 1700 feet above the sea. The materials are largely granite but numerous erratics of Tertiary volcanic rocks indicate Mt. Tacoma as their place of origin.

Prof. T. C. Chamberlin discussed at considerable length several hypotheses bearing on climatic change, atmospheric conditions, and also the succession of ice-sheets in the Pleistocene.

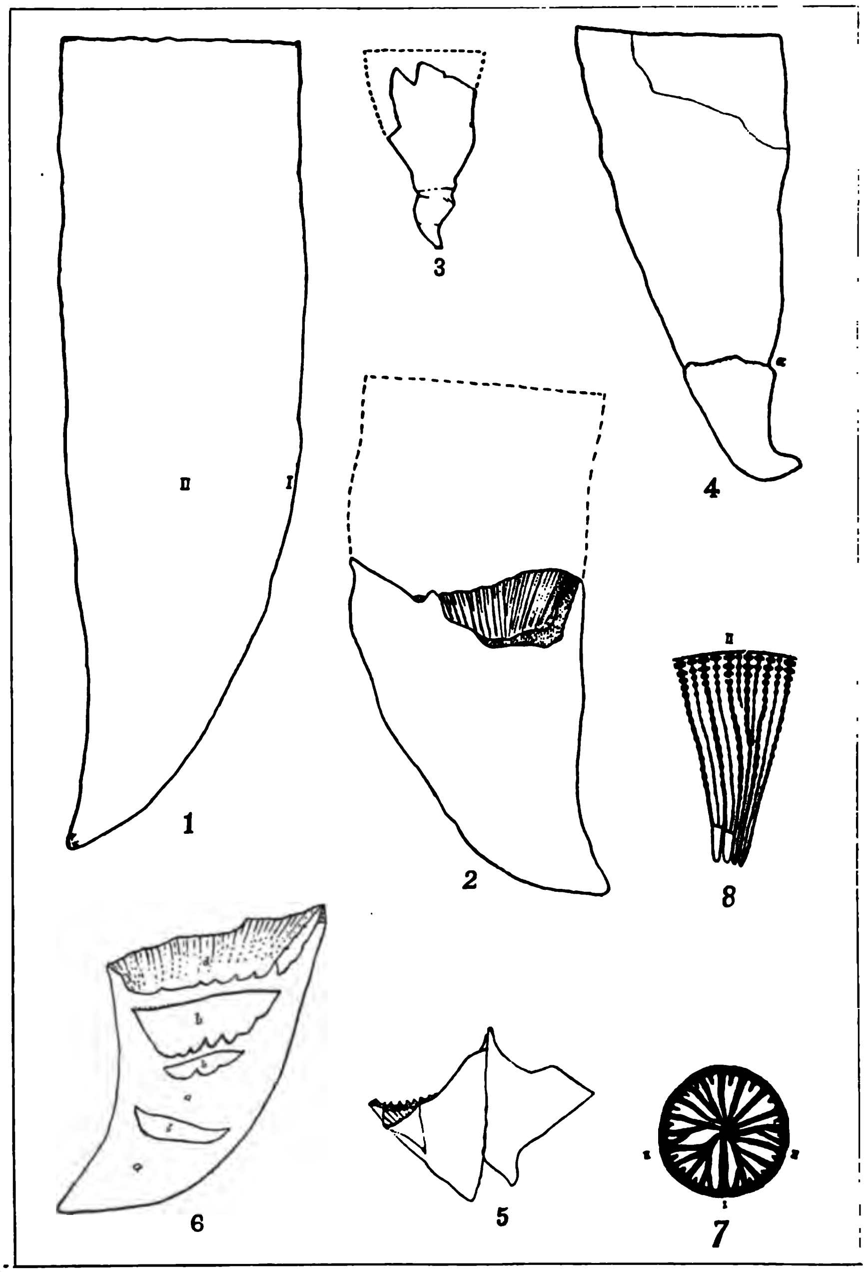
Mr. H. B. Woodward spoke on the English chalky boulder-clay and Dr. Spencer on the continental elevation of the glacial era.

Papers were also presented by Prof. C. H. Hitchcock on the southern lobe of the Laurentian ice-sheet, and Prof. Shaler on the origin of drumlins.

margin of the newly formed tabula rather than upon the centre. Only exceptionally, tabulæ formed above the ends of the septa across the base of the calycle (fig. 6, pl. XVI). They are numerous when formed regularly (fig. 4, pl. XVII), but the number, form, and thickness are very variable in specimens from any horizon and locality, and it does not appear that they are really different in any supposed species of this coral, *S. profundum*. The tabulæ are more inconstant than the septa.

Edwards and Haime (op. cit.) record the fact that the sides of the septa, as seen in the cell opening or calycle of course, are striated, a feature that is well seen in a few specimens. The small ridges or "striæ" on the sides of the septa were developed strongest and most regularly near the bases of the septa, and became irregular gradually, hence they are regular at the cell margin and confused near the bottom of the calycle. There are one to four in 1 mm. Their origin is probably found in the transverse rings or lines which are seen on the outside of the theca, since they appear to be no more than the structural projection of these rugosities, inward through successive increments of the corallum. At first they are arranged in circles parallel to the cell margin, but deeper in the calycle they are increasingly irregular. In thin sections I have detected evidence of them near the bases of the septa only, but on silicified specimens and on interior casts in limestone they are sometimes seen to be continuous with denticulations on the free edges of the septa. The septa had evidently both striated faces and serrated margins and especially at the base of the calycle they were deeply serrate.

In nearly complete specimens, the alternating large and small septa are readily observed. Kunth has pointed out that in corals of this type the major septa (first order) are not older necessarily than the minor ones (second order). At the calycle margin of this species all septa are nearly equal in size, but with distance from the margin those of the first order increase the more rapidly, and unite or "wind" together in the bottom of the calycle, while those of the second order become buried in the "false wall" before reaching the calycle bottom. This gives the appearance in the cell opening as if the minor septa developed simultaneously from between the major ones,



STREPTELASMA PROFUNDUM.

and as Kunth tells of Tetracoralla in general, the four points of septal increase do not exactly keep even. The four quarters into which the circle of septa is divisible, coinciding with the four primary septa, rarely each contain an equal number. In this species the counter or anterior quarters have 5 to 10 per cent. the greater number, but correspondingly right and left quarters are on an average equal, although not rarely unequal. Consequently one need not expect the whole number of septa which is about 120 to be constant.

Increase in the number of septa appears to always cease when the corallum has expanded to nearly its greatest diameter (see fig. 1, pl. XVI) and the long specimens have no increase of septa in that part which I have designated for convenience the senile growth, but only in the expanding portion.

The closeness of the septa to each other varies considerably. In early growth three septa occur in the space of 1mm., in maturer growth on an average two or less or even one to 1mm. occur. In rapidly expanding cells or in rapidly expanding portion of a cell the septa are widest apart. A constriction in circumference does not as far as observed ever reduce the number of septa but only the space between them or their thickness or both are contracted. Quite evidently the variation in coarseness of septa was determined by accident of growth like the rate of expansion of the cell which has been already described. Local conditions might therefore have produced a distinct phase of development such as uniform coarseness of the septa but no such character has been found to prevail in any set of fossils of one locality and horizon, although the average seems to vary in different sets to a certain degree.

The septa unite in the middle of the cell at the bottom of the calycle and are more or less "twisted together." In the attached portion of the apices the septa may be irregular but later they become regular. Soon they become "twisted" or irregularly bent and more or less irregularly shaped tabulæ unite with them in a confused manner. A section across the base of the cell opening in a normal young specimen shows however very clearly the regular order of their union at that stage (fig. 7, pl. XVI), and the "twisting together" of the septa later does not represent a different order of arrangement but

merely disorderly union. It is not apparent that the "twisting" of the septa has any other meaning than that irregular peripheral growth of the theca and slight deviation in the numerous septa caused confusion in the centre where the septa converged. Obviously this is the explanation of the confusion within the early attached portion of the cell, since one side of the cell is distorted and the corresponding septa are disturbed. In tranverse section, it may be added, the septa are not cut at a single stage of their development and in the tabulate portion where the septa are unequal in size above and below each tabula, and are moreover strongly serrate, the appearance of "twisting together" is really exaggerated. Also in natural casts many of the tabulæ and parts of the septa had as a rule been destroyed by masceration and a false impression is gained.

The cell opening is rarely if ever preserved in its exact natural form. The septal margins converged downward (fig. 7, pl. XVII) however and neared the centre most rapidly at the base of the calycle, nearly as usually seen in good specimens. The direction of the tabulæ proves further that the interseptal spaces were not deepest in the centre of the calycle but that the calycle as a whole had a more or less upwardly convex, broad bottom from beginning to end of its growth.

At the base of the calycle in mature specimens a fossula or pair of fossulæ is easily observed. On either side of the cardinal septum are irregular pits each displacing the extreme, free edges of one to three major septa, and connected by a small depression over the edge of the cardinal septum, which however is not displaced nor shortened thereby as far as observed. The cardinal septum is the longest one as a rule. On the posterior side of the alar septa are corresponding pits which although single and narrow, must apparently also be called fossulæ. In thin sections they are not easily made out but on casts and silicified specimens they can be seen. Young specimens do not appear to have fossulæ but since the fossulæ are often inconspicuous and develop gradually it is difficult to determine at what stage they begin.

Conclusion.

There appears to me to be nothing in the above described fossils upon which can or should be based a distinction of them

into two or more species, but on the contrary it becomes more evident now than before to me that but one true species is represented. Large and small specimens, those with acute and with obtuse apices, without and with tabulæ all belong together. What is remarkable, however, is that the one species is the only one of the *Zaphrentidæ* known from either the Trenton or Hudson stage.

Rominger has shown that the winding of the septa seen in this species is no longer to be considered as a distinction of generic rank among species that are related to this one. The genus was originally based upon that character, although Edwards and Haime retained the genus only because they observed no theca which exists in *Zaphrentis*. Rominger proved also that this, the type species of *Streptelasma* has a theca but he retained it as a sub-genus. But probably it will be ultimately reduced to a synonym of *Zaphrentis*. I have not adopted such a change, however, at this time, since the necessary study of other species of the same genus and of other genera, for that purpose would entail much discussion and more than could well be included in one article. If my description of *Streptelasma profundum* prevents the coinage of more unrecognizable species or undefined new genera from these materials it will have accomplished much. The described manner of septal increase which differs in one important respect from the law described by Kunth is not considered of subordinate importance to the chief aim of this paper. It is a subject worthy of special consideration, although, since Kunth (op. cit.) has described this coral in particular, when he deduced his law for the septal increase among the Tetracoralla, the subject is also not inappropriately touched upon in connection with this species.

EXPLANATION OF PLATES XVI AND XVII.

Plate XVI.

Streptelasua profundum (Owen).

1. Side view outline of a large and nearly complete specimen, "*S rusticum.*" I and II, points where the increase of septa ceases. Hudson formation, Richmond, Indiana.

2. A specimen of "*S. corniculum.*" Galena formation, Kenyon, Minnesota.

3. Another specimen of the same showing interrupted growth.

4. A specimen, "*S. rusticum,*" showing a fracture of the corallum at *a*. Hudson formation, Richmond, Indiana.

5. Three specimens of *S. profundum* grown together. Beloit formation, bed no. 5, near Monroe, Wisconsin.

6. A longitudinal section showing large open spaces *b*, in the "false wall" *a*, formed by expansion of septa over a tabula; *d* open calycle. Galena formation, bed no. 6, Kenyon, Minnesota.

7. Transverse section near the apex, × 4, showing the regular arrangement of septa and open spaces left between them. Beloit formation, bed no. 5, Saint Paul, Minnesota.

8. Portion of an interior cast of calycle, ×2. The black lines represent the septa and their "striæ." II alar septum. Galena formation, bed no. 8, Mantorville, Minnesota.

Plate XVII.

Streptelasma profundum (Owen).

1. Transverse section, × 4, of a young corallum, showing *a*, the septa, *b*, the theca. I, cardinal septum, II, alar septa, x, side of the corallum that was attached to a bryozoan. The septa have been etched in the cell-opening and are not normal. Beloit formation, bed no. 4, St. Paul, Minn.

2. Transverse section, × 4, below the tabulate portion of a corallum, showing the "false wall" reaching to the centre. I, cardinal, II, alar, III, counter septum, *b*, theca partly preserved. Hudson formation, Richmond, Indiana.

3. Part of a tangential thin section × 8, *s*, septa, *t*, tabulæ. Hudson formation, Richmond, Indiana.

4. Part of a longitudinal thin section showing the usually thin tabulæ *t*, and intervening septa *s*. Hudson formation, Richmond, Indiana.

5. Side view of a specimen, "*S. breve.*" Beloit formation, bed No. 5, near Monroe, Wisconsin.

6. View into the cell-opening of the same, I, cardinal septa, II, alar septa, III, counter septum.

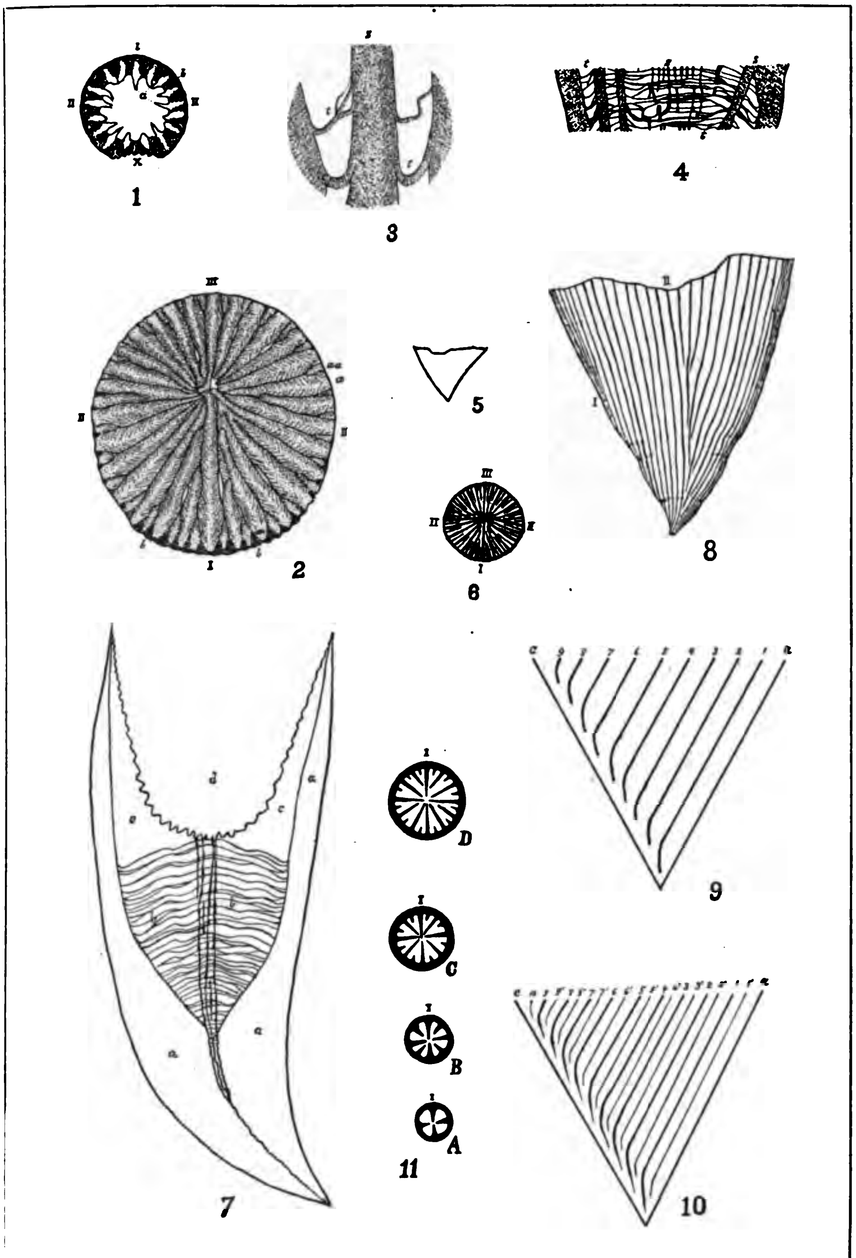
7. Diagram of longitudinal median section. *a*, false wall, *b*, tabulæ between the septa, *c*, free portion of the septa, *d*, open calycle.

8. Side view of a small specimen, × 4. The black lines indicate the furrows in the theca which coincide with the septa in position and show the manner of increase of septa. II, position of alar septum. Beloit formation, bed No. 5, St. Paul, Minn.

9. Diagram after Kunth, to show the manner in which the septa increase in a quarter of a corallum. *c*. cardinal septum, *a*, alar septum, 1-9 other septa.

10. Same as the last, to show more correctly the septal increase in *S. profundum*. *c*, cardinal, *a*, alar, 1-9, other major septa, 1'-9', minor septa.

11. A-D. Diagrams × 5 to show the supposed order of development of the first septa. I, cardinal septum, A, shows 4 major septa, the primary septa, B, shows 8 major septa, C, 8 major plus 8 minor septa, D, 8 plus 4 major and 8 plus 4 minor septa.



STREPTELASMA PROFUNDUM.

THE KOOCHICHING GRANITE.

By ALEXANDER N. WINCHELL, Koochiching, Minn.

On the northern boundary of Minnesota, two miles west of Rainy lake, is an important waterfall. The Rainy river here plunges downward about twenty-five feet over a rock which the full force of the torrent but slowly wears away. This bed rock of the falls is considered to be of eruptive origin, and seems to belong to the Laurentian age.* The river at this point is near the southern edge of the eruption, which extends away to the northeastward for about fifteen miles, while its limits on the north and west are not definitely known.

Macroscopically the rock,† in the region selected, is a crystalline, medium-grained mixture of:

1. A plagioclase feldspar, frequently exhibiting twinning.
2. Another feldspar, exhibiting no twinning, but occasional cleavage.
3. Mica, which is quite abundant and easily distinguished.
4. Quartz, which is less abundant than is common in granites.
5. A green mineral resembling hornblende.

The general color of the rock is dark gray, weathering to nearly black. Weathered surfaces further show that the darker materials (mica and the green mineral) are the first to disintegrate.

A separation of the rock constituents by the specific gravity method resulted as follows:

Mica	12.00	per cent.
Above 3	9.29	"
Between 3. and 2.661	34.66	"
Between 2.661 and 2.642	25.02	"
Between 2.642 and 2.58	7.60	"
Below 2.58	11.43	"
Total	100.00	"

It is almost needless to remark that the accuracy of the determination is much more apparent than real; indeed, 1.95% of the powder was lost in the operations.

*A. C. Lawson: Geol. Surv. of Can. Ann. Rep., 1887. Pt. CC, P. 126F.

†This description is based on specimens 1030G and 1030aG of the series of the Geol. and Nat. Hist. Survey of Minn.

The separation at 3. was not remarkably distinct, while no separation at all distinct could be obtained between 3. and 2.661, and it is therefore considered probable that the rock is somewhat altered, and that many of the grains, though so small,* are not individually homogeneous. The separation at each of the points 2.661, 2.642 and 2.58 was fairly distinct.

Microscopically the following minerals were determined (named in the approximate order of abundance):

1. Orthoclase is quite abundant in irregular grains. Crystal outline was not observed. The grains are frequently rendered cloudy by decomposition, especially to kaolin. Inclusions of biotite, apatite, quartz and hornblende are common, while the very fine gaseous or fluid inclusions are not as common as usual. Carlsbad twins of orthoclase occur but rarely. Micropegmatitic intergrowths with other feldspars can be seen with a high power.

2. Biotite is abundant, being easily distinguishable by its dark brownish color and strong pleochroism. Crystal outline was not observed.

3. Andesine-oligoclase is quite common, showing no crystal outline. Carlsbad twins occur with both parts showing albite twinning. It is not certain that some other plagioclase is not present; but it seems impossible, as every grain which gave a satisfactory test was very near andesine-oligoclase in character, according to the tables of Fouqué.†

4. Microcline occurs quite freely in irregular grains. It usually shows an undulatory extinction, corresponding, perhaps, to the irregular nature of the double twinning. It decomposes to kaolin, epidote and quartz, while biotite and apatite appear as inclusions.

5. Hornblende occurs rather sparingly, perhaps as an original constituent, as no augite has been observed. No crystal form was noted. Zonal structure is seen now and then; inclusions of other minerals are common.

6. Quartz exists sparingly in irregular grains, never showing crystal outline. No cleavage has been observed. Inclusions occur, but not as abundantly as is common in quartz.

*They were put through 72-mesh bolting cloth and supported by 100-mesh bolting cloth.

†Bulletin de la Société Française de Minéralogie. Paris. 1894. XVIII, 428.

Micropegmatitic intergrowths with orthoclase, and apparently also with andesine-oligoclase appear sparingly.

7. Epidote is abundant in small grains. Crystal form is quite common, occurring usually in the midst of biotite. Twinning is rare and twinning lamellæ more rare still. In one case lamellæ are parallel to a short crystal face in a well defined crystal, surrounded by biotite and a bit of quartz. The crystal gives an optic axis, but no good cleavage is visible. In another case (Fig. 1) no lamellæ are visible. Two cleavages are distinctly traceable, and the twinning plane divides the angle between them. The crystal form is again very distinct, though part of it has apparently been broken off. The section

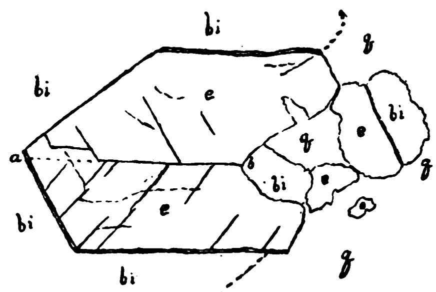


FIG. 1.—Crystal of epidote: *e*, epidote; *a b*, twinning plane; *bi*, biotite; *q*, quartz.

is nearly parallel to the optic plane, and shows an indeterminate interference figure. The twinning is along the line *a b;* the two parts extinguish at an angle of about 7°. It seems probable that this crystal and others quite similar illustrate primary epidote.*

8. Kaolin occurs quite commonly in all the feldspars, and sometimes may be seen closely aggregated. Being the principal decomposition product of the feldspars, it is most abundant in the more highly altered areas, where the vein-like structure of secondary quartz and heterogeneous occurrences of epidote and sphene are found.

9. Apatite is seen sparingly, usually in needle-like forms, sometimes shortened into prisms. These are usually terminated by pinacoidal planes, otherwise by pyramids. Apatite is seldom, if ever, seen without crystal form. Cleavage has

* C. R. Keyes: 15 Ann. Rep. U. S. Geol. Sur. 1893-94, p. 706-10.

not been observed. The crystal form indicates that apatite was one of the earliest minerals solidified; nevertheless, in an area highly altered, apatite needles are so thickly crowded as to suggest at least, a secondary origin.

10. Sphene, or titanite, is in small amount; it has generally a rough crystal outline, the crystals being so small that the biaxial character was determined only after considerable search. Two cleavages were observed, as well as fracture. The pleochroism frequently passes into a shade reminding one of the flesh color of garnet.

11. Tourmaline is identifiable in isolated spots in very limited amount. It occurs in hexagonal crystal form as well as in shapeless aggregates. The pleochroic colors are a very pale blue and a dark grayish blue without a trace of the ordinary violet shade. This is an interesting fact, inasmuch as tourmaline has been found at only one other place in Minnesota.*

12. Pyrite occurs in very minute quantities. Only two grains were large enough to give a really satisfactory color in reflected light. Some of the smaller grains appear to be decomposed; they may be some other iron ore. No distinct crystal outline was observed.

13. Calcite exists in small microscopic grains, as a decomposition product of the feldspars. Only a few grains have been noticed, and the identification is not entirely satisfactory.

14. Zoisite is about as abundant as apatite, and would therefore naturally be mentioned before sphene and tourmaline, but its determination has been so uncertain that it has been relegated to this rank. In ordinary light its appearance closely resembles that of epidote, with which it is associated in origin and occurrence. The crystals are, however, much smaller, and show the characteristic blue-gray interference color.

15. Muscovite is thought to occur in very small quantity. Only two or three microscopic grains were noted. The few distinguishable characters agree with those of muscovite.

16. One more mineral deserves mention. It is a large microscopic twin of a green, strongly pleochroic substance. The

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*Namely, at Pipestone rapids, leading into Basimenan lake.

zonal structure is very noticeable; in the larger part three zones occur, though the inner one may be part of a different

Fig. 2.—A twin (hornblende?)

crystal growth. The cleavage lines are uninterrupted by the twinning plane, although they make an angle of about 19 degrees with it. The larger part of the twin gives an extinction angle of about 26 degrees on the cleavage; the other part one of about 13 degrees. The larger part gives an interference figure which is near an optic axis; the smaller part, one near a bisectrix. One twinning lamella is seen for a short distanee, namely, across the outer zone in one place. Inclusions of quartz and epidote are distinct, while the twin is surrounded by biotite, hornblende, quartz and epidote. The microscopic characters agree, in the main, with those of hornblende, but the extinction angle is inexplicably large. Further, it is difficult to reconcile the position of the twinning plane with respect to the cleavage with any known manner of twinning in hornblende.

Tabulating, to compare the results of the specific gravity determination with the microscopical investigation, we have:

Mineral.	*Sp. Gr.*	*Per cent.*
Biotite	2.8 —3.2	12.00
Muscovite?	2.75—3.2	.....
	Above 3.	9.29
Hornblende	3.2 —3.3	.....
Epidote	3.25—3.36	.....
Zoisite?	3.25—3.36	.....
Apatite	3.16—3.22	.....
Sphene	3.3 —3.7	.....

Tourmaline..3. —3.24	.....
Pyrite.......4.9 —5.2	.....
3.—2.661	34.66
Calcite?.... 2.72	.....
2.661—2.642	25.02
Andesine-oligoclase...2.645	.....
Quartz.....2.65	.....
2.642—2.58	7.60
?	
Below 2.58	11.43
Orthoclase...2.54—2.56	.....
Microcline...2.56	.....
Kaolin.......2.34—2.57	.....
	100.00

Here we have good evidence of the heterogeneous character of the grains in the specific gravity determination, since only a possible trace of calcite falls under the division 3. to 2.661, which includes a third of the whole. This is probably due to the altered condition of the feldspars—the included epidote, zoisite (and apatite?), etc., increasing the weight above 2.661. Similarly, the portion which fell between 2.642 and 2.58 must be chiefly andesine-oligoclase lightened by included kaolin.

On account of this altered character of the rock, only the roughest estimates of the constituent mineral percentages can be made. Basing it mainly upon the fairly accurate determination of the biotite, we would have:

Orthoclase	18.00
Andesine-oligoclase	16.00
Biotite	12.00
Microcline	12.00
Quartz	12.00
Hornblende	10.00
Epidote	7.00
Kaolin	5.00
Apatite	4.00
Zoisite	3.00
Sphene	2.00
Tourmaline, pyrite, calcite and muscovite	1.00
	100.00

The structure of the rock is typically granitic, both macroscopically and microscopically. The specimens studied are considerably altered, but only microscopically. The rock has suffered severe pressure, with a twisting or crushing movement at some time. When it last solidified it doubtless con-

tained biotite, hornblende, quartz, and the three feldspars, orthoclase, microcline and andesine-oligoclase as the essential constituents, with accessory apatite, epidote, sphene, tourmaline, and perhaps zoisite. These accessory minerals all exhibit crystal form, of which they have a complete monopoly. Changes have since introduced kaolin, calcite, pyrite, and perhaps muscovite, and have considerably increased the epidote, apatite(?), zoisite and quartz. The essential constituents and the general structure remain unaltered.

Thus we have a true granite, though remarkably poor in quartz. It has been called a gneiss*; but the gneissic character is entirely wanting in hand specimens, and is only barely traceable in a few small patches at the falls. It therefore seems much better to term it a biotite-hornblende granite.

ON THE MAGNETITE BELT AT CRANBERRY, NORTH CAROLINA, AND NOTES ON THE GENESIS OF THIS IRON ORE IN GENERAL IN CRYSTALLINE SCHISTS.

By James P. Kimball, New York.

(Plate XVIII.)

The well known deposits of magnetic iron ore at Cranberry, Mitchell county, N. C., near the Tennessee border, have only since the year 1867 been systematically wrought, though previously for a long period supplying a local bloomary from their decayed and disintegrated outcrop. Incidentally to an examination of a related magnetite belt in the year 1891, having taken occasion to study the remarkable developments at Cranberry, I now take occasion to indicate their principal features and, as it appears to me, their mode of genesis.†

The locality is at the eastern base of the great Appalachian or Nolichucky plateau, compassed by the bifurcation of the

*A. C. Lawson: Geol. Surv. of Can. Ann. Rep. 2887. Pt. CC. P. 126F.

†Since this paper was mainly prepared a valuable contribution to the study of the same subject by Mr. Henry B. C. Nitze has been published in Bulletin No. 1, (1893) of the State Geological Survey of North Carolina. This first comes to my notice on receipt of a copy from the State Geologist after filing the manuscript of the present pages for publication.

Blue ridge southeast of Roanoke, Va. Hydrographic relations, which it is important to note, are with waters at the western base of the Blue ridge,—that is, between the dominant eastern border of the Appalachians and the great plateau culminating in Roan mountain. The North Carolina-Tennessee line through the plateau country was run over the crowning summit and thence successively over the higher elevations quite independently of given direction, as well as of anything like distinct mountain ranges or ridges, such as are commonly indicated by maps under designations, in order from north to south, of Stone, Unaka, Bald, and Smoky mountains. The drainage of the plateau itself is through the upper waters of the Watauga and Nolichucky, and thus of the Tennessee river. From their very source these waters have sculptured deep channels whose erosion appears to have been independent of folds in the crystalline Archean schists which constitute the mass of the great elevation. When referred to the dominant Appalachian trend, what may be defined as numerous cross ridges, to which erosion of the plateau has given rise, are remnants of *massifs*, few in number, themselves remnants of the great Appalachian uplift. Of these the more prominent have been deeply scored by erosion into radial forms, more or less individual, culminating above the timber line in summits clear of forest. Hence such terms as Bald mountains, and local expressions like the "Balds of the Roan," the "Bald of the Yellow," etc. The latter is a subordinate summit of the Roan mountain *massif*. The remarkably deep and sharp erosion of the Appalachian plateau, promoted by well known conditions of rock-decay in this part of the primitive continental area, is doubtless due to excessive precipitation ever favored by obvious meteorological and topographical conditions.

The openings of the Cranberry mine are near the eastern base of Cranberry ridge, a steep and lofty elevation (4015 ft.) which has been sculptured from the mass of the Big Yellow spur of Roan Mt. by waters of the Elk. Similar, but less continuous elevations separated by other water-courses of the same stream rise one above another toward the summit of Roan Mt.

So much, in brief, for the rugged topography surrounding

the Cranberry mines. With the discovery and even natural development of the ore deposits, the configuration of the surface has had much to do. This likewise comes into view in considering either possible future discoveries along extensions of the Cranberry ore belt, or the relations of the so-called Roan Mountain ore belt of east Tennessee.

The narrow bottom of Cranberry creek some 50 feet below the mines is occupied by the iron works and railroad (E. Tenn. & W. N. C.) both built by the Cranberry Iron and Coal Co., of Philadelphia, and operated as well as the mines by that company. The works consist of a single small blast furnace, built in the year 1884, making about twenty tons of iron per day from a 43 per cent. ore, ordinarily with Flat-top or Pocahontas coke. The furnace is chiefly remarkable for its production of iron with a tenor of phosphorus as low as 0.020 per cent. from an ore of comparatively low grade, an achivement in regular practice probably unequalled in the country. This result is due not only to the remarkably minute proportion of this deleterious substance in the furnace stock, but to the care and skill exercised by the president, Mr. Frank Firmstone of Easton, Pa., who has devoted much personal attention at the furnace to the production of iron of high grade.

The Cranberry ore belt enters conformably into the structure of the series of crystalline schists in Cranberry ridge. This structure is a succession of folds whose longer axes are transverse to the axis of the Cranberry bottom or to the trend of the ridge itself. The strike of the ore belt, conformably to the axes of the folds, is N. W.-S.E. The dip accordingly is southwest and at an average of 45°. A ravine down the side of the ridge, opening out into the Cranberry bottom, has eroded the reverse or northeast dip of the anticline into which the ore belt enters, so that the ground compassed by the Cranberry workings presents simply a monoclinal structure. The topographical position of the mines may therefore be further described as on the southwest side of a cross ravine heading near the crest of Cranberry ridge as indicated by a minor depression or wind gap.

The zone of rock decay is so deep in this region that petrographic studies are far from satisfactory. For this reason I have not attempted to correlate the surrounding schists. I

am able to note only in a general way a marked change in the lithologic type at the cross ravine suggestive of the Huronian succession or contact. While the schists on the northeast side seem to be exclusively acid, the mine schists opposite are essentially basic, pyroxene and amphibole predominating. Massive amphibolite is the prevailing rock for several miles to the south. Tucker hollow, back of Cranberry ridge, has been excavated from this formation. Much of its detritus. weathering with exfoliation of ferric oxide into rounded forms, externally resembles limonite. This circumstance has led without discrimination to a futile search for this ore on the Perkins tract. On the state geological maps the Cranberry mine is made to appear within the Huronian area. This is an error. But the concealed Huronian contact is probably in Cranberry ridge, and very close to the mines, that is, not far back of the railroad bank and in part coincident with the cross ravine above mentioned. This probability rests upon the assumption that the weathered amorphous and sharply folded schists exposed in the railway cuts represent that division of the Algonkian series.

The ore developments at Cranberry, though somewhat obscurely defined, are in the form of lenses or lenticular masses differentiated by the presence of magnetic iron ore within the compass of a remarkably persistent stratiform belt of pyroxene passing into amphibole, the former prevailing. This passes into epidote and magnetite by alteration. The marginal material of the ore lenses is highly epidotic especially in the upper workings. Here transition from pyroxene into magnetite is notably through a margin of epidote. While the interior parts of lenses are characterized by moderately rich or concentrated magnetite free from epidote, the lenses may be said to graduate outward into pyroxene-epidote of low grade. The more crystalline as well as the richer ore possesses the cleavage of pyroxene and is free from epidote. Genesis of the magnetite from pyroxene thus appears to be indicated on the one hand with development of epidote, and on the other hand, in the case of rich crystalline and more or less distinctly pseudomorphic magnetite by replacement without development of epidote. Epidotization of pyroxene from weathering action is practically limited to

Vertical Projection, Cranberry Mine. (1891.)

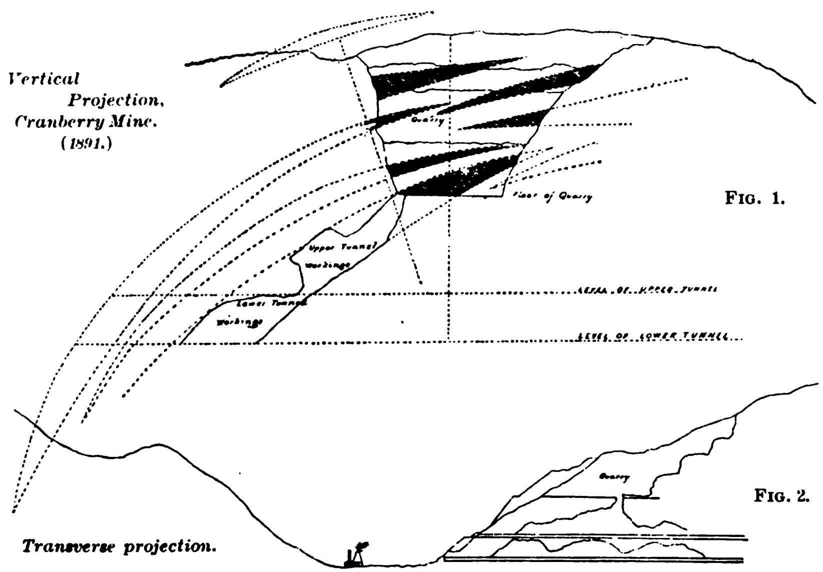


FIG. 1.

Transverse projection.

FIG. 2.

SECTIONAL SKETCHES, CRANBERRY MINE.

the superficial zone of rock-decay, and is mainly exhibited in the upper workings. This indeed increases with proximity to the surface.

Epidotization of amphibole and pyroxene is likewise a characteristic of shallow or superficial portions of the larger magnetic lenses of Asche county in the same state. The ore developments in that part of the New river basin occupy the same relative topographical position with reference to the Blue ridge and Stone Mt. as the Cranberry mines. Their stratigraphic environment is also similar. The old bloomaries on Helton creek and other waters of New river, like the old Cranberry forge, had their ore supply from float ore, and iron sands *in situ*, the latter from decayed outcrops of epidotic magnetite lenses, and stratiform augitic material irregularly altered into epidote and magnetite, and probably appertaining to a single stratigraphical horizon. A number of sharp folds present a series of such deposits the parallelism of which is due to replication. At numerous localities in the New river basin the exhibition of float ore is remarkable, though in point of quality and as indications of important deposits in place uncommonly deceptive. The best of this material owes its extraordinary purity to secular weathering. This is shown by its vesicular condition as a result of disintegration and elimination of silicates. Float of this description is especially characteristic of what has been distributed by ablation and gravity from the smaller or thinner lenses or plates. Indeed—according to my own experience in Asche county, the exhibition of this enduring kind of ore detritus is apt to be the more imposing the less the size or importance of the original deposit.

The Cranberry mine is wrought partly in open quarry and partly by levels, the separate workings being connected on the dip. Parts of six distinct ore lenses are exhibited on the face of the quarry one above another and in echelon. These, defined in short as differentiations or concentrations of magnetite in the augitic belt, pass insensibly into non-feriferous material. The lowermost of these, the largest of the series, is likewise wrought in the underground workings.

The lower level 330 feet in length enters the ridge directly beneath the railroad bank 30 ft. above drainage, or 95 ft. be-

low the level of the quarry floor at nearly right angles with the strike of the formation. It therefore cross-cuts members of the formation next below the horizon of the ore-belt and just penetrates the hanging wall of the main ore-body. These members are essentially foliated and gnarled hornblendic gneiss only slightly epidotic at this level and sparsely strewn with zircons. The thickness of the ore-body on the tunnel line is 87 ft. Measurements, however, vary with the section, and, apart from a few as already given, exact dimensions remain undetermined. Exploration by diamond drill 142 ft. beyond the innermost heading reveals alternations of ore and pyroxene and amphibole more or less epidotic. This goes to show the presence if not the maintenance of ore-lenses at this level the same as in the upper workings, but none of remarkable thickness. Their indication is rather of the attenuation of lenses or concentrations of which larger sections are exhibited in the face of the quarry. The lack of sharp demarcation in the ore lenses renders boring unsatisfactory as a mode of exploration. The following inverse section was recorded:

	Excavation	Gneiss more or less ferriferous...	101 ft.	
		Main ore body at adit level......	70 ft.	
6 ft.	"	Ore...........................	6 ft.	
29 ft. 8 in.	"	Epidotic gneiss................	23 ft.	8 in.
34 ft. 8 in.	"	Interval......................	5 ft.	
38 ft. 2 in.	"	Ore...........................	3 ft.	6 in.
41 ft. 11 in.	"	Ore and amphibole (pyroxene?)	3 ft.	9 in.
42 ft. 3 in.	"	Good ore......................	0 ft.	4 in.
46 ft. 10 in.	"	Interval......................	4 ft.	7 in.
88 ft. 6 in.	"	Good ore......................	41 ft.	8 in.
142 ft. 3 in.	"	Interval......................	53 ft.	9 in.

The lower workings have been carried upward so as to open into earlier workings connecting with the upper tunnel, so-called, 35 ft. higher, or 65 ft. above water level. This was driven through about 80 ft. of talus round a turn of the hill-side so as to reach the ore belt on the strike, and therefore nearly at right angles to the lower tunnel now in use. It thus gives access to a portion of the main ore body on the dip intermediate between the quarry and the lower workings, and especially to solid ground not yet penetrated from the lower level but still below the level of the quarry. Ore broken on this level can be delivered through the lower level, the two workings having been "holed" through on the foot wall.

Underground workings thus connected rise to near the floor of the quarry, at the nearest edge of which at one point they break through to daylight. The thickness of the main ore body at the level of the upper tunnel is 65 ft. The difference in section at the two tunnels is due to the lenticular configuration of the ore lens. All of the workings advance in the direction of the strike. Neither workings on the strike exceeded 400 ft. in length in the year 1891, and 40 ft. in hight, while both are driven into solid ground beyond the vertical of the quarry face.

The quarry face is advanced from the floor and from two benches above, the former being 45 ft. above the upper level. Three working breasts are thus maintained each 50 ft. in hight. Abandoned shallow excavations still higher on the hillside expose an upper lens. These were wrought for the sake of iron sands from disintegration of this small superficial division of the ore belt. The face of the hillside now occupied by the present quarry was originally wrought in the same way for the supply of the old bloomary.

The thickness of the ore belt at the surface as shown by graphic construction is about 250 ft. including the upper lens, or 205 ft. to the superficial edge of the quarry, these measurements being at right angles to the dip. The horizon of the foot wall is clearly defined in the lower tunnel, at which level the ore developments, judging from the boring, seem limited to a thickness of 152 ft. The upper and middle divisions of the ore belt are disclosed in the quarry face, though nothing like a hanging wall has been reached in any of the workings. From the present compass of the quarry it has been eroded.

Of any given thickness of the ore belt only a varying portion is made up of workable ore. A large proportion of the refuse is adapted to magnetic separation or concentration. From the above description it will be understood that besides the main ore body which crosses the whole quarry face, passing on the rise into the right wall, attenuating parts of five lenses similarly disposed are wrought in the quarry all of which in the summer of 1891 could be more or less distinctly traced by coloration. It also appears that the net thickness of the differentiated ore lenses varies at intervals with the section.

The following analyses of Cranberry ore are of samples typical of three distinguishing grades, only the first analysis (I) representing anything like the average properties of the ore as prepared for market. This was made by Mr. Edward Riley of London, England, from a sample taken by himself in the month of October 1890. The other samples, collected by Mr. Bailey Willis and analyzed by Mr. A. A. Blair* represent (II) pure magnetite, and (III) a mixture of epidote and magnetite. The admixture of pyroxene and epidote is indicated by notable proportions of lime. In a 43-per cent. ore as used at Cranberry furnace, seven per cent. of the iron produced is attributable to ferrous and ferric oxides in silicated form, from pyroxene and its derivative (epidote) respectively. The pure pyroxene according to an analysis by Mr. Blair contains 24.01 per cent. of metallic iron.

	I.	II.	III.
Silica	20.97	5.27	29.99
Ferric oxide	47.32	62.57	25.05
Ferrous oxide	16.45	26.68	18.93
Alumina	2.87	1.18	10.07
Manganous oxide	0.42	0.22	0.76
Lime	10.10	1.46	11.33
Magnesia	1.43	0.55	1.78
Iron disulphide		0.20	0.18
Nickel sulphide		0.04	0.09
Sulphur	0.02		
Carbonic acid		0.08	0.07
Titanic acid		0.95	
Hygroscopic water	trace	0.35	0.37
Water of composition	0.91	0.49	1.49
Phosphoric acid		0.007	0.024
	100.49	100.037	100.134
Metallic iron	45.93	64.64	32.37

The sculpturing of the valley of Cranberry creek has been transversely through the ore belt. Its southeasterly extension has been traced to the opposite side by means of an excavation now fallen in. In an opposite direction its extension is strongly indicated. Nothing has been done to decide the question of continuity.

With the use of the plane table and magnetic needle, but with little or no help from the latter instrument, I have endeavored to trace the northwest extension of the Cranberry ore-belt.

*U. S. Census 1890, XV, p. 326.

On the Hardigraves or Ellis tract in low ground near, if not within the F. P. Perkins line, a shallow excavation made several years ago, reveals terminal parts of two overlapping lenses with a dip of only 10° SW. This position is on the projection of a right line from the northwest ore bank of the Cranberry Co., passing directly over the outcrop of the Cranberry ore belt, that is—just to the south of the quarry. The encasing schists are characteristic of the belt as typified at Cranberry. The strike and persistence of the belt are thus imperfectly indicated. The upper part of it however has here been eroded, and the thickness of the part preserved remains to be ascertained by excavation. Further in the same direction the ore belt disappears by erosion, or recedes to the south at a gentle dip in the low ground where the outcrop is concealed.

A second ore-belt characterized by a remarkable development of pyroxene, both crystalline and schistose, outcrops in almost vertical attitude on the summit of a high divide on the F. P. Perkins tract, on a line of strike parallel to that of the Cranberry belt, about 1700 ft. to the eastward. A thickness of 3 to 4 ft. of magnetic gossan, or decayed epidotic magnetite, blended with ferric hydrate, has here been opened at the summit of a sharp hill to a depth of 30 ft. This is overlain by contorted hornblendic gneiss and underlain by pure subcrystalline pyroxene over 20 ft. in thickness. The dip to the southeast passes out of the perpendicular from near the surface to 70° at the bottom of the pit. The gneiss has been penetrated from a tunnel driven at the base of the hill toward the hanging wall, The relation of the encasing schists is accordingly the reverse of the succession at Cranberry. Lithologic analogy however points to an identity of horizon, and the stratigraphic relations of the two belts to those of an overthrust anticlinal fold.

The Roan mountain ore belt can be studied to but little advantage at present for lack of exposure or industrial development. The high estimate of its importance published from time to time rests mainly on assumptions not altogether justified by a number of feeble and unsystematic attempts to produce a merchantable grade of ore. It embraces the Citico mine near Shell Creek station, belonging to the Citico and

Roan Mountain companies, and undeveloped discoveries on the Stratton, DeBardeleben, Heupscup, Crab Orchard and so-called Magnetic tracts, the last at South Watauga belonging to the East Tennessee Mining and Improvement Co. Other discoveries have been made on the Roan Mountain Iron and Steel Co's. tract.

These tracts form a chain several miles in length rounding the base of Roan Mt. A sample of the ore from the "Magnetite Mine" taken by Mr. Jeremiah Head of Middlesborough, England, in 1890, closely resembled, according to an analysis by Pattison & Stead of that city, the average of Cranberry ore. A considerable proportion of the iron was, as in the case of the Cranberry product, evidently in silicated form, and contained in the accompanying pyroxene as indicated by the large percentage of lime. This analysis free of oxygen and moisture is printed in Mr. Head's report on the mine etc., as follows:

Iron	43.75
Alumina	4.66
Lime	9.94
Magnesia	3.05
Silica	21.90
Sulphur	0.02
Phosphoric acid	0.01

The Citico mine when visited in the year 1891 had been abandoned. A series of small lenses at shallow depths had been exhausted. The ore produced was of indifferent quality, but a small part of the ore on the stock pile being up to shipping grade.

Of the ore belt as a whole at Cranberry little or no polarity is sensible at the surface, yet stripped ledges and broken remnants of ore lenses as left in excavation, especially below the zone of rock decay do not, on the contrary, fail to exert a powerful influence on the magnetic needle, as observed inside the Cranberry workings and quarry. The same is the case at the one opening of the western ore belt, and only negative results were obtained in efforts to trace its extension.

The dipping and horizontal needle of at least *hand* instruments therefore afford little or no aid in the search for iron ore in this region, notwithstanding a moderate degree of polarity in broken fragments of sound ore, and even in specimens of

the gossan. The reasons are not far to seek. First, as the course of the ore belt is almost at right angles to the magnetic meridian terrestrial magnetism prevails over all but intense local attraction under exceptionally favorable or artificial circumstances as above instanced. Second, as every separate lens acts as a single magnet the overlapping of lenses of unequal size, as well as overlapping of opposite terminal parts of separate lenses within the compass of the pyroxene belt, tends to neutralize their opposite polarity. Both positive and negative polarity thus acting together produce no appreciable effect upon the short needles of simple instruments. Third, the disintegration of the ore lenses to a considerable depth, as commonly observed in this latitude, also tends to impair the polarity of the nearest original ore lenses, while lower and less decomposed parts of deposits are unfavorably influenced by the law of decrease of magnetic intensity in measure of the square of the distance.

Besides such difficulties from the small measure of resultant magnetic intensity, particularly in the case of complex development of ore lenses, the greatest difficulty of all opposed to a detailed magnetic survey is from the density of the forest. And it is doubtful whether a systematic survey in spite of the obstacles instanced would afford satisfactory results as in the Archean iron fields of New York and New Jersey where glacial erosion has cleared the way for work of this kind by removal of the inert zone of rock decay. Instruments of precision would here be required like the field magnetometer and transit, while as a preliminary a rectangular sectional survey would be indispensable in order to establish fixed points for magnetic observation and comparison.

One of the more interesting occurrences connected with the ore belts is the development of homogeneous sub-crystalline pyroxene to a remarkable thickness. At the opening on the western ore belt above referred to this attains a thickness from 20 to 30 ft. In the eastern or Cranberry ore belt the thickness is much greater, though the pyroxene is less homogeneous through weathering alteration. Whatever may have been the mode of accumulation of this material, the magnetite associated with it appears to have been derived as well as the pyroxene itself by molecular separation or differenti-

ation from a highly basic aggregate originally constituting this division of the Archean schists. This division, there is some reason to believe, is near the top of their stratiform development in this region.

I have referred to the ore deposits at Cranberry as lenses. Yet they lack the definition of concrete ore bodies, or at least outlines of definite form. They may be more accurately described as lenticular concentrations of magnetite in pyroxene with their longer axes conformable to the lamination or divisional structure of the enclosing schists, and graduating into pyroxene more or less epidotic. While rich aggregates of magnetite are occasionly met with, the bulk of the ore is an admixture of the two minerals along with, though rarely, a few accessory minerals like quartz and calc-spar representing, together with epidote, derivative or residual products of alteration of uni-silicates or silicates, not in atomic combination. The separation of magnetite is also incidental to this alteration, as we may well believe. The breaking up of basic aggregates whether eruptive or clastic into schistose products by molecular and physical *deformation* has come to be commonly described of late as a process of *differentiation*. These are simply new and convenient terms for phenomena long since described by Bischof followed by many other writers.

I have elsewhere described external local separation or differentiation of specular oxide of iron from a stratiform and probably stratified amorphous basic aggregate in the Cle Elum valley in the eastern foot hills of the Cascades in Kittitass county, in the state of Washington. The circumstances here point indubitably to molecular alteration incidental to weathering action. Several years ago I also published descriptions of superficial and otherwise local differentiation or concentration of specular ferric oxide from basic eruptive rocks strictly in circumstances favorable to weathering action. I refer to outcropping parts of dykes and more expansive intrusions of basic diorite on the south shore of the island of Cuba, in the neighborhood of the very remarkable developments of specular iron ores the origin of which I was enabled to trace to replacement of emerged and disrupted coral rock.* I have also described in previous pages of the GEOLOGIST numerous other occurrences of the same type on islands of

*Am. Jour. of Sc. [3] XXVIII, 416; Trans. Am. Inst. Min. Eng. XVIII, 613.

British Columbia* and have referred to still others in culminating regions of the Cascade Mts. of Washington.

These several examples falling under my own observation, together with the very notable occurrences at Cranberry, all illustrate, though on widely different scales of economic importance, local differentiation of iron ores due to hydro-chemical or so-called metasomatic permutations. Beyond the ultimate effect produced, in neither example is there much in common with *original* differentiation of magnetite and basic silicates from eruptive magmas as claimed by Brögger and by Vogt to have been the mode of genesis of certain magnetic iron ores in Norway and Sweden. Assuming for the moment the correctness of the conclusions of these excellent observers, it will be perceived that apart from conditions of magnitude and importance the occurrences above noticed closely simulate the isolation or concentration of titaniferous magnetite graduating, as shown by these authors, from this extreme of basicity to less basic and finally acid differentiations from eruptive magmas. Yet on general grounds it seems open to suspect that even in the examples given by Vogt differentiation of iron ores at least may have been accentuated if not produced by slow progressive molecular or metasomatic alteration and replacement. Among identical secondary products alike from eruptive rocks, and from progressive alteration or molecular deformation of clastic rocks are magnetic and specular oxides of iron from basic material indifferently, whether eruptive or metamorphic. The instability of basic rocks of either classification compels extreme caution in deciding between primary rocks of this description aud derivative products. I have taken previous occasion to comment more particularly on the same important point.†

The genesis of magnetite at Cranberry both concentrated and more or less blended proceeded hydro-chemically, as may be conceived, from an originally basic aggregate—in part during the process of induration and crystallization, and likewise subsequently and even secularly, aided perhaps by molecular affinity and especially by mutual attraction and flow of magnetic molecules. Evolution of the magnetic oxide of iron from protoxide in uni-silicates is proof that here, as in

*Vol. xx, 1897, p. 13.

†Am. Jour. Sc. [3] xxviii, 429.

every other paragenesis of this mineral, partial peroxidation has supervened for the production of ferric oxide in atomic ratio with ferrous oxide. Saturation of ferrous oxide with ferric oxide for this evolution is indeed all that has arrested peroxidation of the lower oxide short of completeness wherever original silicates have been split up by oxidation of this unstable base under weathering influences. Hydro-chemical as well as thermo-dynamical agencies in eruptive paragenesis of magnetite have doubtless been far more active than in a metamorphic paragenesis. Physical differentiation or magmatic concentration of magnetite as such into concrete ore bodies from molten eruptives, as urged by Vogt, is scarcely conceivable without supervention of further physical or molecular concentration analogous to what takes place both in metamorphic and eruptive aggregates. No basic rocks even among the most modern can ever be assumed to retain their original condition or inter-molecular form.

There seems much however to support the theory that differentiation in molten eruptives may summarily take place in the order of specific gravity toward the borders of a magma basin, or, on the Soret principle, toward the marginal parts of dykes or other intrusions, with the effect of a determination, not necessarily in stochiometric proportions, of material richest in ferrous oxide to such a position relative to the mass. Hence of course the greater basicity of silicates and also the greater the subsequent evolution of magnetite in nether parts of intrusive masses, sometimes so as to afford the *locus* of ore bodies through slow hydro-chemical permutations. That concentration of magnetite has taken place in any given eruptive magma except as a product of secondary evolution seems to me extremely doubtful, as in the case of all other bodies of iron ore closely related to basic rocks—notably metamorphic rocks. The subject of physical differentiation of igneous magma antecedent to development of crystalline types of igneous rocks has been presented by Prof. Iddings in a manner which leaves little room at present for further citations of results of studies given to the same subject by Brögger, Vogt and others.*

*Iddings. Bull. Phil. Soc. Washington XII, 1892, pp. 89, 214; Vogt. Zeitsch. für. prak. Geol. I, 1893, pp. 4, 125, 257; III, 145, 367, 444, 465.

Note. Since the presentation of this paper an exact discussion of this hypothesis has been given by Becker. (Am. Jour. of Sc. III, 1897, 21.)

DICERATHERIUM PROAVITUM.

(Plate XIX.)

By J. B. HATCHER, Princeton University.

In this journal for May, 1894, pp. 360-361, the writer described under the name of *Diceratherium proavitum*, a member of the *Rhinocerotidæ* new to the White River formation. In my original description of this species I was unable to see the proof sheets and hence some typographical errors appear in the text, and in at least two instances erroneous characters are assigned to the type. It is the purpose of this brief paper to correct those errors in my original description and to give further reasons in favor of placing this form in the genus *Diceratherium* rather than *Aceratherium*.

The type consists of a nearly complete skull (No. 10965) of a fully adult, in fact rather aged, individual, without the lower jaw. The principal specific characters are as follows: Skull rather short, low and broad especially in the region of the frontals; superior surface slightly concave antero-posteriorly; sagittal crest short, low and broad; strong postorbital processes on frontals; nasals very strong, partially coössified and bearing upon their upper and outer surfaces a pair of rugose prominences situated at about one-third the distance from their extremities to their junction with the frontals. These prominences resemble very much the rugosities supporting the nasal horns in many of the recent rhinoceroses, and doubtless served the same purpose in *D. proavitum*. Behind this pair of rugosities the nasals are constricted, but posteriorly they expand again to meet the broad anterior border of the frontals. The fronto-nasal suture is but little in front of the orbit. In front of the pair of rugose elevations the nasals contract rapidly and are directed downward and forward. The occipital crest is emarginate in the median line and overhangs the occipital condyles. The zygomata are rather slender but stronger than in *Acerotherium occidentale*. The post-tympanic and post-glenoid processes are in contact but not co-ossified. The anterior border of the posterior nares is situated just behind the posterior edge of the first molar. Of the teeth only the molars and premolars are preserved in the type and they are rather too much worn to determine accurately their characters. The first premolar

is rather strong and well developed, the succeeding premolars increase in size from in front backward. The dorsum of the molars and premolars is very flat with no suggestion of a median costa. There is a basal ridge on the dorsum of the true molars but not on the premolars. The median sinus is shallow, especially in the premolars and the first molar; it is obstructed by only faint rudiments of the crochet and antecrochet. The anterior and posterior valla are shallow. There is a cingulum on the inner border of the premolars but none on the true molars. The principal measurements of the type are as follows:

	mm.
Length of skull from extremity of nasals to occipital crest	475
Breadth across frontals at post-orbital processes	165
Hight of occipital crest above foramen magnum	115
Width of nasals at rugosities	102
Width of nasals just in front of rugosities at sec. shown in fig. 1a.	63
Thickness of nasals on median line in front of rugosities	24
Length of premolar--molar series	195
Length of premolar series	97

Prof. Osborn* has considered *D. proavitum* as a synonym of his *Aceratherium tridactylum*. In his latest communication on this subject he says: "The large number of skulls in the collection belonging to *Aceratherium tridactylum* demonstrates that the species ran to two extremes, a high, long and narrow type, and a shorter, lower and broader type. The latter exhibit very prominent rugosities upon the nasals, which we might, with Hatcher, interpret as prophetic of *Diceratherium* were it not for the fact that equally rugose areas are found above the orbits and upon the zygomatic arches."

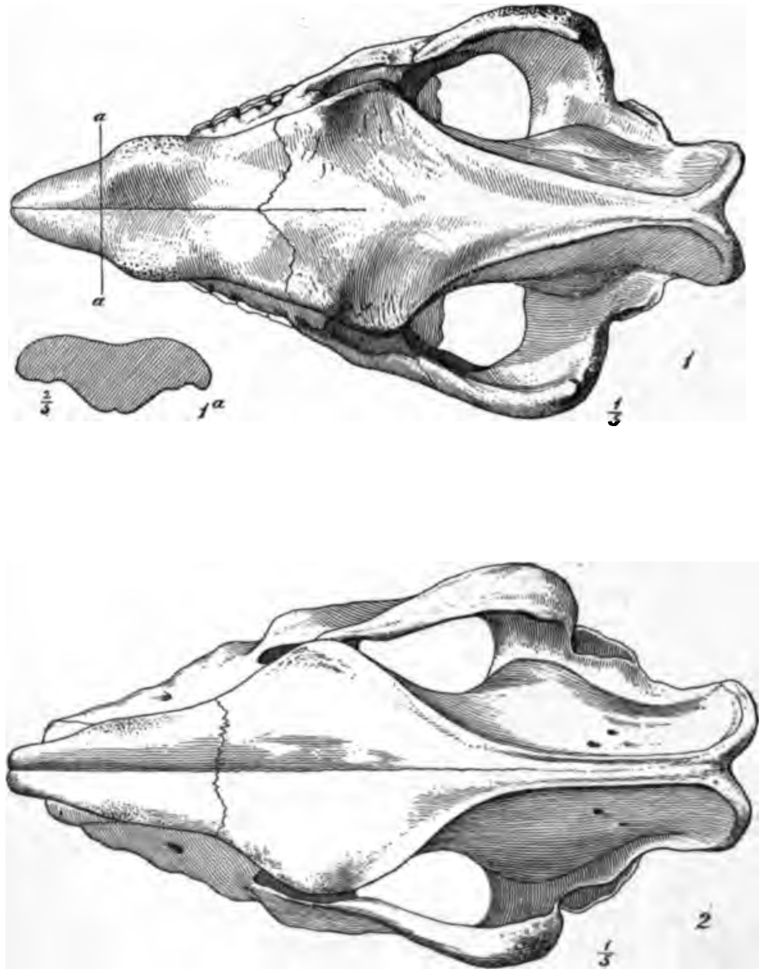
"These two varieties of *A. tridactylum* are not due to age, but may be partly sexual. The molar structure has no constant differences."

Prof. Osborn† in his original description of *A. tridactylum* says: "The occiput is high and rather narrow" and again in a more recent description he says:‡ "In the *type* the nasals are *perfectly* smooth, (italics mine), but in another skull (No. 541) the nasals exhibit a pair of rugosities which at once suggest the possession of a pair of horns, and Mr.

*See Bull. Am. Mus. Nat. Hist., vol. VII, 1895, p. 373.

†See Bull. Am. Mus. Nat. Hist. vol. V, 1893, p. 86.

‡See Bull. Am. Mus. Nat. Hist. vol. VI, 1894, p. 207.



DICERATHERIUM PROAVITUM *and*
ACERATHERIUM TRIDACTYLUM.

Hatcher has recently shown that this species is followed by another, related to the John Day genus *Diceratherium* Marsh. The distinctive features of the skull are the high, narrow occiput and powerful sagittal crest, etc."

From the above it will be seen that the *type* of *A. tridactylum* belongs to the series, with skulls characterized by Prof. Osborn as high, long and narrow and in which the "nasals are perfectly smooth"; while the type of *D. proavitum* pertains to the other series with skulls characterized by Prof. Osborn as shorter, lower and broader and with prominent rugosities upon the nasals.

As shown by the above quotation Prof. Osborn has stated that these two varieties are not due to age, but that they may be partly sexual. In view of the fact that we do not find in the skulls of recent rhinoceroses or other perissodactyls similar sexual variations, I think it fair to conclude that these variations are not sexual, but of generic and specific importance. I therefore retain *Diceratherium proavitum* as distinct both generically and specifically from *Aceratherium tridactylum* Osborn; unless we abolish altogether the genus *Diceratherium* and with it *Aceratherium* and call them all *Rhinoceros* as has been done by Flower and Lydekker,* but which does not seem advisable.

Prof. Osborn's objection to considering the rugosities on the nasals of *D. proavitum* as indicative of horns because he finds similar rugosities on the zygomata and over the orbits can scarcely be considered tenable, since the latter rugosities are not in a position at all relative to that known to have been occupied by horns in later forms from the John Day beds, and very similar rugosities may be seen on the zygomata and over the orbits in the recent rhinoceroses which are known to bear horns on the nasals.

Aside from the rugosities, there are other evidences even more in favor of considering them as having borne horns; such as the great thickening of the nasals (shown in fig. 1a) in order to give them the necessary strength to support the horns, and the low, short and broad sagittal crest as shown in fig. 1. Furthermore, the geological horizon (*Protoceras beds*) in which the type was found is just that in which we

*See Mammals Living and Extinct, pp. 410-411.

should expect to find the ancestor of the John Day form. When the latter beds shall have been as carefully explored as have the White River beds there will doubtless be found a series of forms running gradually from *D. proavitum* in the *Protoceras beds* to *D. advenum* Marsh in the John Day. The rugosities in the former species are, it is true, not nearly so prominent as in the latter, but they are in the proper position, and that they supported incipient horns is shown by every collateral character which we should reasonably expect to find in the White River ancestor of the John Day form; it should therefore be considered as ancestral to that form.

I present here for comparison in figs. 1 and 2 the sup. view of the type of *D. proavitum* and a reproduction of Prof. Osborn's figure showing same view of *A. tridactylum*. The rugosities on the nasals in the latter as shown by Prof. Osborn's descriptions in the text and as stated by the draftsman are taken not from the *type*, but from another skull, referred to the same species. In fig. 1 the broad nasals, entirely concealing the premaxillaries, the position of the fronto-nasal suture and the low, short, broad sagittal crest are especially noteworthy as contrasting with the same characters in fig. 2.

Fig. 1. Sup. view of type of *D. proavitum* (No. 10965) 1-5 nat. size.

Fig. 1a. Cross-section of nasals immediately in front of horns, two-fifths nat. size. Drawn by R. Weber.

Fig. 2. Sup. view of *A. tridactylum*, 1-5 nat. size, after Osborn. Drawn by R. Weber.

The principal distinctive characters of *D. proavitum* and *A. tridactylum* may be tabulated as follows:

D. proavitum.	*A. tridactylum.*
Skull rather short, low and broad. Nasals very thick, broad, and with prominent rugosities on sup. surface. Fronto-nasal suture only a little in front of orbits. Sagittal crest broad, short and low, almost disappearing.	Skull long, high and narrow. Nasals slender and perfectly smooth on sup. surface. Fronto-nasal suture situated well in front of orbits. Sagittal crest high, long and narrow.

THE FISHER METEORITE. CHEMICAL AND MINERAL COMPOSITION.

By N. H. Winchell, Minneapolis.

For the purpose of further determination of the mineral which resembles maskelynite, two micro-chemical tests were made. The particles are so small that no chemical examination is practicable; viz.:

1. Particles belonging to group 2, i. e. glass.
2. Particles of a translucent mineral which showed angular fracture, and but little or no cleavage, presumed to be the doubly refracting mineral which is like maskelynite, and possibly represented by groups 5 and 6.

With the first the test revealed lime and a little soda. With the second were developed, along with fluosilicates of lime, a liberal sprinkling of hexagonal rods of fluosilicate of soda.

There is not enough of this mineral present to warrant an attempt at quantitative analysis. It remains therefore undecided whether the meteorite contains maskelynite. The evidences in favor of its presence are:

1. A feebly polarizing mineral, low in double refraction, occurring in the midst of the chondri and elsewhere.
2. This mineral shows little or no cleavage.
3. It contains lime and soda.
4. The glass from which it seems to have crystallized also contains soda, and no soda has been detected in the other minerals.*

Chemical Analysis of the Fisher Meteorite.

By C. P. Berkey, University of Minnesota.

An analysis was made of some small fragments of this meteorite. Preliminary qualitative tests showed the following elements: Silicon, aluminium, iron, nickel, calcium, magnesium, and sulphur. Silicon occurs as the oxide, forming the mineral *tridymite* and also occurs in the silicates *maskelynite*, *olivine*, and *enstatite*. Aluminium, calcium and magnesium and a part of the iron occur in the silicates. Nickel is present native or possibly forming an alloy with the iron. Iron is present in three forms, metallic iron, ferrous oxides in the silicates, and ferric oxide chiefly as an oxidation product from the native metal.

Sulphur is present in small quantity in the mineral *troilite*. No alkali metals were found.

The bulk analysis gave:

*Unavoidable obstacles have delayed the conclusion of this examination. The reader is referred to this journal for former accounts of this meteorite, viz, vol. XVII, pp. 173, 234, and to *Comptes Rendus des Séances de l'Académie des Sciences*, Paris, 16 Mar. 1896.

should expect to find the ancestor of the John Day form. When the latter beds shall have been as carefully explored as have the White River beds there will doubtless be found a series of forms running gradually from *D. proavitum* in the *Protoceras beds* to *D. advenum* Marsh in the John Day. The rugosities in the former species are, it is true, not nearly so prominent as in the latter, but they are in the proper position, and that they supported incipient horns is shown by every collateral character which we should reasonably expect to find in the White River ancestor of the John Day form; it should therefore be considered as ancestral to that form.

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printed pages that have been devoted to these terranes; but which, in too many cases, is left wholly screened under the vagueness of presentation, or is left to be adjusted by some later investigator, who, not being familiar with the locality nor with the precise scope of the terms already employed, doubles the difficulty by duplication or division. There is, therefore, no legitimate recourse open to the present generation of geologists but to resort to the "law of priority" in the selection of terms for stratigraphic divisions, and to relegate to synomymy all later terms applied to the same formations, so soon as it is sufficiently demonstrated that the formation named in the two countries, or in neighboring states, really is the same.

There is, of course, one other method to be pursued, a practice that is introduced into the United States by the United States Geological Survey, viz.: begin *de novo*, re-examine and remap all the formations previously mapped and named, and apply to them new terms, ignoring all previous designations. That may be justifiable on the part of a grand national survey, from some points of view, but from others it is not. Indeed, it is quite unjustifiable and unjust, from the historical point of view, and also will serve in the distant future to breed still greater confusion and discord; for, however great the present authority with which results are reached and names applied to the formations, the future will certainly furnish a greater and a more exact science, and our present labors will be considered juvenile in comparison with those, and will perhaps be swept into the waste-basket with as little compunction as we so treat the labors of our own predecessors. Therefore geological nomenclature cannot be considered stable, except momentarily, unless it be based, as already stated, on the *law of priority*, same as in the biological sciences.

This basis of nomenclature Prof. Renevier has adopted, and that gives to his scheme a standing value and durability which will commend it for many years to all geologists.

Unfortunately one geologist cannot compass fully the literature, and judge of the value of all the contributions from all parts of the world. The author of this paper therefore advised with many European fellow-geologists, and it may be

Silica	SiO_2	41.16	per cent.
Alumina	Al_2O_3	6.60	" "
Iron	Calculated as Fe	24.26	" "
Magnesia	Mg O	19.03	" "
Lime	Ca O	4.34	" "
Nickel	Calculated as Ni	2.26	" "
Sulphur	S	traces	
	Total	97.65	per cent.

In the above analysis all of the compounds appear in the correct chemical combination with the exception of iron and sulphur. Sulphur should appear as FeS, but the small amount obtained made such estimate impracticable. A part of the 24.26% of iron should be estimated as Fe O and also a part as Fe_2O_3 which will then bring the analysis to the proper total amount.

The lacking 2.35% should properly be accounted for in this way. 6.89% of iron disposed of in this way satisfies the chemical proportions.

EDITORIAL COMMENT.

The Geological Chronology of Renevier.

There is published in the *Compte Rendu* of the sixth session of the International Congress of Geologists, Zurich, April, 1897, an extended review of geological stratigraphy, by Prof. E. Renevier, of the University of Lausanne. This paper is a re-edition of a previous scheme of the sedimentary formations, and hence it embodies the results of long study on a subject to which the author has devoted much labor. It deserves, therefore, to be received with a cordial welcome, and despite its errors, if such it has, the geologists of the world will render their gratitude to Prof. Renevier for a sincere and persistent attempt to systematize the stratigraphic nomenclature of their science.

It goes without saying that it is vain to attempt to satisfy all, in such a work. There are so many special phenomena, viewed by so many different geologists, from so many points of view and under so varied opportunities of reaching the truth, that much confusion and even of contrariety of opinion have arisen, a fact which sometimes is plainly reflected from the

printed pages that have been devoted to these terranes; but which, in too many cases, is left wholly screened under the vagueness of presentation, or is left to be adjusted by some later investigator, who, not being familiar with the locality nor with the precise scope of the terms already employed, doubles the difficulty by duplication or division. There is, therefore, no legitimate recourse open to the present generation of geologists but to resort to the "law of priority" in the selection of terms for stratigraphic divisions, and to relegate to synomymy all later terms applied to the same formations, so soon as it is sufficiently demonstrated that the formation named in the two countries, or in neighboring states, really is the same.

There is, of course, one other method to be pursued, a practice that is introduced into the United States by the United States Geological Survey, viz.: begin *de novo*, re-examine and remap all the formations previously mapped and named, and apply to them new terms, ignoring all previous designations. That may be justifiable on the part of a grand national survey, from some points of view, but from others it is not. Indeed, it is quite unjustifiable and unjust, from the historical point of view, and also will serve in the distant future to breed still greater confusion and discord; for, however great the present authority with which results are reached and names applied to the formations, the future will certainly furnish a greater and a more exact science, and our present labors will be considered juvenile in comparison with those, and will perhaps be swept into the waste-basket with as little compunction as we so treat the labors of our own predecessors. Therefore geological nomenclature cannot be considered stable, except momentarily, unless it be based, as already stated, on the *law of priority*, same as in the biological sciences.

This basis of nomenclature Prof. Renevier has adopted, and that gives to his scheme a standing value and durability which will commend it for many years to all geologists.

Unfortunately one geologist cannot compass fully the literature, and judge of the value of all the contributions from all parts of the world. The author of this paper therefore advised with many European fellow-geologists, and it may be

true to say that, for the distinctively European terranes, especially for all those later than the Paleozoic, the classification which he has adopted, and the nomenclature published, will be found acceptable to the great majority of geologists, the world over. This cannot be said of the Paleozoic, and especially of the Lower Paleozoic. His list of advisers embraces no American, and among the English he names Lapworth only. While, therefore, the face of his "Résumé du chronographie chronologique" to an American has a decidedly European aspect, to the English geologist it must present an aspect decidedly continental. Perhaps the most remarkable feature in the tabulation is a rather promiscuous sprinkling of American terms near the bottom of the table, for they are inserted without due reference either to their significance and scope, or to their proper correlation. The most of the late American researches on the lowest stratified rocks are not expressed, and, strange to say, having chosen Lapworth as collaborator of the Silurian, he sets aside Lapworth's judgment on an important question of stratigraphy and nomenclature relating to North American Paleozoic, and introduces, in the foremost rank, as characteristic and authentic, some American terms that are but rarely seen in recent American literature devoted to this horizon. Following is the author's arrangement of the bottom of the Paleozoic and the older rocks:

Periode ou Système.	Époque ou Série.	Age ou Étage.	Synonymes généraux les plus usités.
Silurique	Silurien	Ludlovien Wenlockein Landovérien	Gothlandien ou Silurien supérieur.
	Ordovicien	Caradocien Landeilien Arénigien	Silurien infer. ou Cambrion supérieur.
	Cambrien	Potsdamien Ménévien Géorgien	Trémadocien. Acadien. Taconien (Lapw.)
Archéique	Huronien	Kéweenien Pébidien	Précambrien ou Algonkien.
	Laurentien	Arvonien Dimétien Lévesien	Archéen. Azoique. Protozoique ou Eozoique.

There are several striking features, which we will not here designate errors, to which attention may be specially directed:

1. The Silurian, as a system, covers and includes the Cambrian, and the term Cambrian is reduced to the rank of such a term as Ordovician.

2. Silurian as an epoch is made to include only what is usually known as Upper Silurian.

3. The terms Upper Silurian and Lower Silurian are given as synonyms, the former of "Silurian" and the latter of Ordovician.

4. The Taconic is placed above the Keweenawan.

5. The Taconic is given as a synonym of the Lower Cambrian, on the authority of Prof. Lapworth, who, according to the author, wished to substitute it in the scheme for the term Georgian.

6. The Keweenawan is placed in the Huronian, that being the position in which the rocks it includes were placed by Logan and Murray when they first defined the Huronian.

7. The whole space occupied by the above is about one-sixth of the space of the whole column of formations, which expresses a wrong idea of the relative time which they represent in geological history; it is probable that these terranes consumed, in their accumulation, as much time as all subsequent geological time, and to them have been given as much study and as much literature as to all the later formations combined.

8. The Arvonian and Dimetian are placed in the Laurentian, but the Pebidian is put in the Huronian; whereas, according to Sir Archibald Geikie, these are intrusives and belong in the Lower Cambrian.

It is evident to any geologist who is familiar with the geology of the Lower Cambrian and of the Archean, that this is a very inadequate and incorrect presentation. It is further evident that it is difficult, perhaps impossible, for any geologist who has spent his time for several decades in the study of the stratigraphic distinctions of the Tertiary and of the Mesozoic, to fairly understand the magnitude of the earlier terranes, or to apprehend the great place they occupy in the history and the literature of the science.

Rohn's Collection of Lake Superior Rocks.

It is a pleasure to commend to geologists the collections of rock specimens illustrating the petrography of the lake Superior region, which have been prepared by Mr. Oscar Rohn of Madison, Wisconsin.

The collections are of a high order of excellence. The specimens are of the freshest material from localities selected under the supervision of professor Van Hise and are of remarkably uniform and correct proportions.

They are accompanied by large chips for the preparation of thin sections. They illustrate the pre-Cambrian formations of a classical region and are rendered increasingly valuable by the references which accompany each specimen to the works of Pumpelly, Marvine, Irving, Van Hise, Lawson and Bayley.

It is possible, with such a collection, to master the petrography of this famous district to a degree which would be otherwise unattainable.

The remoteness of the region and the expense of a journey render a visit impracticable to the average student.

Such typical illustrative material, systematically described by high authorities, assists in the understanding of all metamorphosed crystalline rocks and is invaluable to educational institutions and to students of pre-Cambrian geology in any country. F. B.

The Terminations -ic and -ical.

There is much confusion in the use of these affixes, and the following rule, promulgated by the U. S. Geological Survey, is not only authoritative and well founded, but has been very generally adopted by the geologists of the United States.

N. H. W.

27. To insure uniformity of practice in the spelling of a large class of scientific words ending in ic and ical, as geologic, geological, geographic, geographical, etc., the following preferences are suggested for the consideration of those who demur to the practice of dropping the al entirely—the only usage deemed consistent with the claims of an improved orthography:

(a) Terms designating natural phenomena, relations, conditions, products, etc., may end with ic.

(b) Terms designating the works of man—research, literature, speculation, etc.,—may end with ical.

Applying these rules to the terms geologic and geological for example we get:

Geologic formation,	Geological survey,
structure,	map,
conditions,	bulletin,
relations,	report,
evidences,	exploration,
period,	hypothesis,
age, time, etc.	society.

("Suggestions for the preparation of manuscript and illustrations for publication by the U. S. Geological Survey." By W. A. Croffut. Jan. 1892. P. 8.)

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Syllabus of General Geology for Students, with definitions and references. By CHRISTOPHER W. HALL. (8vo, 127 pp.; Minneapolis, The University Book Store, 1897.) This syllabus, planned as a guide for students in the study of the general principles of geology, is intended more especially for the use of the author's classes in the University of Minnesota. Hence there is considerable of local illustration and attention is called, by excursions when possible, to those geologic phenomena which find expression in the vicinity of Minneapolis. This feature, however, will by no means destroy the usefulness of the syllabus in other institutions of learning, as the purely local matter can be disregarded and similar material for any locality can be supplied by the instructor.

The subject is divided into two parts—physical geology and historical geology. Under the first are included geo-dynamics, structural geology, physiographic geology and mineralogy; while under the second are petrographic, paleontologic and stratigraphic geology. This manner of division is followed throughout the syllabus excepting on the sixth page where the author presents his general classification of the science of geology, dividing it into three main sub-divisions,—geography, petrology and paleontology. The first includes meteorology, oceanography and physiography; the second, geo-dynamics, structural geology, mineralogy and petrography; and the third, paleobotany, paleozoology and stratigraphy.

There are two important characteristics of this syllabus which render it possibly unique among geological syllabi,—first the presence of definitions and second the wealth of detail. The definitions are numerous, but brief, and in many of them the wording is that of the author. In this connection it is interesting to note that the exact wording of any definition, adopted by a geologist, as evinced in the numerous text books on this science, frequently differ slightly from that given by any other writer in this line. The size of the syllabus (127 octavo pages of brevier type) is an indication of the amount of detail which it contains. This detailed treatment of the subject represents a great amount of work on

the part of the author and will be of advantage to the student who is already somewhat acquainted with the elements of geology. But the reviewer questions the advisability of presenting so much detail to the student who is totally unfamiliar with elementary geology, and who has only a brief period, possibly one or two terms, to devote to this subject. But at the same time to the teacher who must present the subject thus briefly and to the somewhat advanced student this character of the syllabus will appeal favorably. U. S. G

The Glacial Lake Agassiz. By WARREN UPHAM. Monograph xxv, U. S. Geological Survey: 4°. xxiv, 658 pp. 38 pls. Washington, 1896. Geologists on both continents have awaited for some time the appearance of this elaborate monograph on the great glacial lake which once occupied central North America, whose features had been partially described in previous papers by Mr. Upham aud touched upon by other observers. The several years devoted by Mr. Upham to the field work and elaboration of results bear excellent fruit in the carefully digested and admirably arranged discussion found in this volume which made its appearance a few months ago. The work so well begun under the Minnesota Survey has been greatly increased in value by the extension afforded by the United States and Canadian Surveys.

After a general introduction outlining the lake area and early observations, together with methods of study pursued by the author, the reader is made acquainted with the physical features of the area covered by the lake and of neighboring districts. The geologic formations underlying the drift are then discussed and their relationship to the physical features briefly touched upon. These formations are discussed both in the light of surface outcrops and of deep well records. The author concludes that the greater part of the area of lake Agassiz was once covered by Cretaceous deposits and that the main physical features have been produced in post-Cretaceous time by processes of denudation following a widespread or epeirogenic uplift. A broad plain or base leveled region was formed far below the uplifted Cretaceous surface, whose reduction to base level is thought to have occupied not only the Eocene and Miocene periods but also most of the Pliocene. This base leveled region, stretching from the Rocky mountains eastward to the Archæan hills on the east border of lake Agassiz, and northwestward past Hudson bay is thought to have been drained in Tertiary time into the Atlantic between Labrador and the southern point of Greenland. An uplift of this base leveled region followed in the late Pliocene, during which the trough of lake Agassiz is supposed to have been formed. The depression of Hudson bay beneath the sea is referred to the time of culmination and departure of the great ice sheet. The course of the pre-Glacial rivers flowing from the Cretaceous area west of lake Agassiz after the late Pliocene uplift, was probably northeastward across the Hudson bay basin. The present channel of the Missouri river, as shown by general Warren and professor Todd, dates only from the Glacial period. The pre-Glacial drainage of the upper Missouri watershed may have occupied the James

river valley and led northward from it or perhaps continued across it eastward to the Red River of the North.

Following this discussion there is a brief review of the Glacial period in North America and discussion of glacial deposits. A map of the glaciated area of North America shows the position of the "Wisconsin" boundary as well as the older Glacial boundary and of lakes Bonneville, Lahontan and Agassiz. The courses of glacial movement are indicated more completely than in any map of North America before published and several pages of text are covered with a list of striæ in the north part of the continent, presented as an appendix to the volume. The shifting or change in direction of ice currents in Minnesota and neighboring districts, which was brought to notice some years ago by Mr. Upham, is here treated in connection with a description of the several moraines of the Wisconsin series. Very little attention is given the older drift sheets of America, and the intervals of deglaciation by which they are separated from each other and from the Wisconsin drift. As a consequence the discussion may give the impression that the production of the Wisconsin series of moraines occupied the greater part of the Glacial period, a view which the author would certainly not wish to maintain.

The history of lake Agassiz which forms the central theme of the paper is introduced by a brief reference to the evidence by which the former existence of glacial lakes is recognized, five evidences being noted as follows: (1) Their channels of outlet over the present water parting; (2) cliffs eroded along portions of the shore by the lake waves; (3) beach ridges of gravel and sand; (4) delta deposits formed by inflowing streams; and (5) fine sediments spread widely over the lacustrine area. Of these evidences the one most definite in its testimony to the influence of the ice sheet is the lake outlet. These outlets in several cases are found leading away from basins which are now drained by continuous descent in the opposite direction. The basins present no indication that the lakes were formed by any land barrier across their lower portions, which has since been removed by erosion or by depression. The case is made very strong where shore lines that connect with the former outlet are found to rise in elevation when traced toward the present outlet instead of sinking in that direction, as they would do if there had been a removal of the barrier by depression. That such is conspicuously the case with the shores of lake Agassiz has been brought to notice in earlier papers by Mr. Upham and is well shown in the course of this monograph. In view of this clear evidence against the occurrence of a land barrier it seems remarkable that the hypothesis of a land barrier, as the cause for lake Agassiz, should have been favored by professor Dana in the last edition of his Manual. (See pp. 947-948, 985-986). Lake Agassiz is but one of several glacial lakes which existed in the northern United States and Canada and the occurrence of several of these glacial lakes is briefly touched upon by Mr. Upham.

Evidence is produced to show that lake Agassiz became gradually

extended northward with the departure of the ice sheet. This evidence consists not only in the occurrence of morainic belts in the basin occupied by the lake, but also in the absence of the upper beach in the northern latitudes. The upper or Herman beach can be traced on the west side of lake Agassiz from the outlet northward to the north part of the Pembina escarpment, a few miles north of the international boundary, but has not been found farther north. During the time occupied in the formation of the Herman beach four moraines were formed and the ice border withdrew about 150 miles in Minnesota and 150 to 200 miles in North Dakota and southern Manitoba. Mr. Upham thinks it probable that the border withdrew not less than 300 miles in the Red River valley, where lake Agassiz produced a more rapid breaking down of the ice margin than on the neighboring land surfaces. At the close of this stage of the lake the outlet had been cut down at least 25 feet and possibly 50 feet but this erosion was entirely in glacial deposits.

At the close of the Herman stage the lake probably had an area of about 26,000 square miles but it is thought to have subsequently expanded to at least 100,000 square miles or about the combined area of Wisconsin and Illinois and considerably more than the combined area of the five great Laurentian lakes. Before northeastward outlets began to drain lake Agassiz the border of the ice sheet had probably been melted back from the present lake Winnepeg far toward Hudson bay and the outlet at the south had been cut down to a depth of about 90 feet below the level of the Herman beach. With the uncovering of the Nelson river, lake Agassiz ceased to be held by the ice barrier and became *lake Winnepeg.*

In the south part of the area of lake Agassiz five principal beaches have been observed and named from towns in Minnesota near which they are well exhibited, the Herman, Norcross, Tintah, Campbell and McCauleyville beaches. These beaches separate into distinct beachlets when traced north into Manitoba, there being seven beachlets corresponding to the single Herman beach at the southern outlet, two beachlets each for the Norcross and Tintah, and three each for the Campbell and McCauleyville beaches. After the lake obtained its earliest outlet to the northeast it formed fourteen shore lines. There are thus thirty-one separate shore lines in the northern portion of this lake area and nearly all extend south of the international boundary. The changes in level during the period of southward discharge are due principally to differential northward uplift, only a small element of change being due to lowering of lake level by erosion of its outlet. The author estimates that there was a slight uplift of the outlet amounting possibly to 90 feet but perhaps not exceeding 50 feet. The north part of the basin was uplifted 200 to 300 feet or more, the amount becoming greater from south to north. The beaches on the eastern shore are uplifted more than those on the western and the ratio of the eastward ascent to the greater northward ascent indicates that the uplift was from south-southwest to north-northeast. The changes of levels were

nearly completed during the existence of lake Agassiz while the ice sheet formed a barrier to prevent free drainage to Hudson bay from lake Winnepeg and the Red River of the North. A slight change in continuation of this uplift has, however, taken place since the ice sheet ceased to be a barrier. In discussing the causes for the changes of levels it is shown that two causes, gravitation of water toward the ice sheet and changes in temperature of the earth's crust due to the ice sheet, are of minor consequence, and that epeirogenic movements are the chief cause. The author concludes that crust deformation by the ice sheet is an important, if not the main cause of the changes of level, there being downward movement beneath the thicker part of the ice followed by a partial return to the pre-Glacial attitude upon the disappearance of the load at the close of the Glacial period. He inclines to the view that there is plastic material at depths of but a few miles which was displaced somewhat by the sinking of the earth's crust under the ice weight and which flowed back by gravitation when the load was removed, thus restoring the crust approximately to its former position. In this connection attention is called to the fact that epeirogenic movements have been close accompaniments of glaciation throughout the world, and a causal relationship between these movements and glaciation is inferred.

The duration of lake Agassiz is estimated from the size of the outlet and the strength of the beaches to have been included within a period not more than one-seventh the length of the period since the ice sheet disappeared from the Laurentian highlands. This period the author thinks to be but 6,000 to 8,000 years in length, his estimate being based upon various measurements and computations by independent investigators concerning the length of post-Glacial time. The duration of lake Agassiz is, therefore, placed at 1,000 years or less. The great deltas on its borders, formed by inflowing streams, which in some cases contain several cubic miles of material, are thought to have been built up largely from the deposits contributed by the melting ice sheet, while still covering the head water portions of the valleys with which they are connected. Their bulk in some cases is more than sufficient to fill these valleys. It is, therefore, difficult to make an estimate of the duration of the lake by a measurement of these deltas. In the reviewer's opinion few of the time estimates upon which Mr. Upham's calculations are based are substantiated by such accurate data as are brought forward in support of his estimates and conclusions on other subjects. The treatment of time relations is at present necessarily somewhat defective both because of the meagerness of available data for computation and the imperfections in method of calculating. The wide range in recent estimates of the duration of Niagara falls (from 3,500 years to 32,000 or more) illustrates the uncertainty of such computations as are used by Mr. Upham in determining the duration of lake Agassiz.

Thus far shells of but five species of mollusks have been found in the beaches discussed in this monograph. These are all fresh water

species. In the beaches connected with the southern outlet a single species has been found. *Unio ellipsis* Lea, a common species of the upper Mississippi region. The remainder are found in a beach connected with a northeastern outlet. The scarcity of life in this lake may support the view of brief duration, though the coldness of the waters was probably influential in checking the spread of molluscan life. There appears to have been a general absence of life in other glacial lakes of the northern United States and Canada throughout most of their existence. As yet it is not known that any of them became restocked with life until glacial conditions had ceased their influence.

About 200 pages are devoted to a detailed description of the shores of lake Agassiz, embracing the author's work and additional data furnished by Mr. J. B. Tyrrell, of the Canadian survey. These descriptions are accompanied by a series of maps which set forth the distribution and relations of the beaches very clearly. The monograph throughout is well illustrated by maps, views and diagrams.

In addition to the discussion of the history of this region a comprehensive statement concerning its economic resources is presented. Sixty pages are devoted to the artesian and common wells of the Red river valley, and analyses of their waters. The use of artesian water for irrigation is briefly discussed. The agricultural resources of the far famed wheat belt are given forty-two pages and the geological resources which are rather meager are given eight pages. There are two appendices, one presenting a table of glacial striæ, the other notes concerning the aboriginal earthworks found within and near the area of lake Agassiz. F. L.

The Glacial Brick Clays of Rhode Island and southeastern Massachusetts. By N. S. Shaler, J. B. Woodworth, and C. F. Marbut. (From the Seventeenth Annual Report, U. S. Geol. Survey, for 1895-6, Part I, pp. 951-1004, with two plates and ten figures in the text: Washington, 1896.) The average thickness of the till in eastern Massachusetts is estimated about 15 to 20 feet, and the proportion of its material which has the same character as the stratified clays and finely pulverized rock flour forming the beds described in this report is thought to be only about ten per cent. Therefore the extensive and thick beds of fine stratified drift found at low levels, and chiefly northward at the mouths of valleys, from New Jersey to Nova Scotia, derived from the glacial erosion, are regarded as proof that the North American ice-sheet, like the glaciers of Switzerland, discharged far more of its englacial drift by subglacial streams than the part which remained in the moraines and general sheet of till. From the absence of ripple marks and current bedding, Prof. Shaler infers that the coast was depressed several hundred feet, being covered to that extent by the sea adjoining the receding ice-front, when these clays were deposited.

The geological sequence and geographical distribution of the clay beds of this region are described by Mr. Woodworth, with a careful discussion of the time relations of the glacial and stratified drift formations in Nantucket, Martha's Vineyard, and Block island, and on the main

land northward. He recognizes three stages or epochs of glacial advance, divided by intervals of recession: and he refers the deposition of the stratified clays mainly to the closing part of the second glacial epoch. This appears to correspond with the Iowan glaciation in the Mississippi basin, with its attendant deposition of the greater part of the Mississippi valley loess.

Marbut and Woodworth, in the third chapter of this paper, give many details of the clays about Boston, where they estimate that the marine submergence at the principal stage of clay deposition exceeded 100 feet. Sections of thick stratified clays are found in a few places overlain by till: and in Somerville such later till is amassed in drumlins. The bedded clays, referred to the time of glacial retreat at the beginning of the last interglacial stage or epoch, are believed to have been covered and largely eroded by a subsequent great ice advance which reached south to the terminal moraines of Nantucket and Cape Cod, Martha's Vineyard, and Block and Long islands.

This paper is noteworthy as the first to claim for the Atlantic seaboard a series of glacial advances and recessions similar to those of the interior of the United States, with a very long interval between the earliest and the latest glaciation. The conclusion that the great recession of the ice-sheet accompanied with the deposition of the stratified clays, from near the farthest limit of glaciation back at least to Boston, was followed by a re-advance to almost the same limit as before, is not so fully supported as the greater Iowan glacial re-advance, which indeed apparently belonged to an earlier time in the Glacial period. No remains of an interglacial soil and forest are discovered in New England, nor eastward of Ohio, like those which farther west lie beneath the Iowan till.

W. U.

The Moraines of the Missouri Coteau and their Attendant Deposits. By JAMES EDWARD TODD. (Bulletin No. 144, U. S. Geol. Survey, pp. 71, with 21 plates and three figures in the text. 1896.) The chief theme of this bulletin is a detailed description of the looped and complex series of marginal moraines which were accumulated on the borders of the Dakota lobe of the ice-sheet during its retreat from the Missouri river on the boundary between Nebraska and South Dakota, northward to the Northern Pacific railroad. Four stages of the glacial recession are marked by concentrically parallel belts of very knolly and bouldery drift, which, however, in some parts of their courses interlock and merge one with another. Lake Dakota, which occupied the valley of the James river for some time after the ice-lobe was melted away, is shown to have attained a length of 170 miles, a maximum width of 25 miles, and a depth of about 150 feet. Numerous plates, reproduced from photographs, present very clearly the various types of scenery and drift formations of the prairie plains and hills of the Dakotas east of the Missouri river. W. U.

Glacial Observations in the Umanak District, Greenland. By GEORGE H. BARTON. (Report B of the Scientific Work of the Boston Party on the Sixth Peary Expedition to Greenland, Technology Quarterly, vol. x,

pp. 213-244, with a map, thirteen plates, from photographs, and eight figures in the text; June, 1897.) This finely illustrated paper treats of the inland ice and its valley glaciers in the region of the large Umanak fjord, at lat. 71 degrees, near the middle of the west coast of Greenland, including the Karajak, Itivdliarsuk, and many smaller glaciers. The ice borders are always very steep to a hight of 20 to 40 feet or more, being often precipitous, vertical or overhanging. Nearly everywhere they exhibit distinct layers, and the upper ice layers in some places project and appear to have moved forward faster than those next below. Very little drift was seen inclosed in the ice, even near its base; but well defined moraines adjoin the ice front or are sometimes separated from it by a stream fed by the ice melting. Evidence of recent and long continued glacial recession was observed. During the maximum extension of the Greenland ice-sheet, it is shown, by its erosion and rounding of the rock outlines, that it filled the Umanak fjord, enveloping its islands and the contiguous Nugsuak peninsula, and reaching beyond the present outer coast line. Likewise the ice-sheet of Baffin land is known to have flowed out into Baffin bay. The author therefore raises a question, which perhaps can never be certainly answered, whether these ice-sheets from the east and west became confluent, passing thence southward where the present sea is about 2,500 feet deep in Davis strait. With the greater preglacial altitude of the land, such extension of the arctic ice fields seems possible or even probable, while yet the mountain tops on the border of the high Greenland plateau may have risen at the same time as nunataks above the ice surface. W. U.

A Handbook of the Genera of the North American Palæozoic Bryozoa. By GEORGE B. SIMPSON. (Fourteenth Annual Report of the N. Y. state geologist, 1897, pp. 403-668, pls. 1-25.) The laudable interest of Prof. James Hall in the younger generation of palæontologists, after having provided us with the excellent guide to the study of the *Brachiopoda* by professors James Hall and John M. Clarke, now presents us with a translation of Felix Bernard's Principles of Palæontology, and a "Handbook of the Genera of the North American Palæozoic *Bryozoa*" by George B. Simpson.

The latter work will be especially welcome to students, as the geological and palæontological importance of the much neglected bryozoans has steadily increased since their rich development in the older formations of North America became known.

The handbook begins with a historical introduction, in which a great amount of widely scattered literature has been used to show the development of our present conception of the bryozoans. A bibliography of the living forms, covering the time from 1599 to 1885, accompanies this chapter. This literature has further served to give a quite complete description of the anatomy and development of the bryozoans, the understanding of which is aided by numerous illustrations.

The restriction of the following chapter on the classification to an enumeration of the families and genera is wise on account of the still unsatisfactory condition of the classification of the bryozoans. In

agreement with the educational character of the work, Mr. Simpson takes a decided stand against "giving too much weight to microscopical characters, which not one student in ten can detect, to the neglect of more obvious characters, which can be observed by any student of ordinary scientific penetration." This refers especially to such microscopical characters as, for instance, have been found in the structure of the cell walls, and which not only needs the trained eye of the microscopist to be detected, but which also must have been changed by the process of fossilization. A rather regretable result of the author's regard for the defects of the students is the omission of a chapter on the fossilization and methods of study of these forms, which, on account of Mr. Simpson's great experience in investigating these mostly minute fossils. would have brought out much valuable information.

A bibliography of the fossil bryozoans of North America and an enumeration of the genera and species of American palæozoic bryozoans with references to authorship and the geologic formation in which they occur, are further given. 146 genera and nearly 1,100 species are enumerated.

The principal part of the work, the description of the families and genera, is accompanied by numerous text-illustrations and 25 plates of generic illustrations, which, drawn by the author himself in his well-known artistic and careful manner, undoubtedly constitute one of the most attractive and valuable features of the hand-book. The following new families: *Intraporidæ*, *Actinotrypidæ*, *Clathroporidæ*, *Thamnotrypidæ*, *Arthroclemidæ*, *Rhomboporidæ*, *Bactroporidæ*, *Chilotrypidæ*, *Fistuliporinidæ*, *Odontotrypidæ*, *Ceramoporellidæ*, *Reptaridæ*, and the genera: *Lyroporidra*, *Anastomopora*, *Thamnocella*, *Stictocella*, *Stictoporina*, *Fistuliporina*, *Fistuliporella*, *Ptilocella*, *Fistuliporidra* and *Fistulicella* have been created. The *Fistuliporidæ* are regarded by the author as true bryozoans, because forms of *Fistulipora* gradually pass into other genera, undoubtedly *Bryozoa*. The monticuliporoids are also placed with the bryozoans, though the author is convinced that further study will show that some of the forms, at least, must be associated with corals. As Mr. Simpson remarks in the introduction, "there is but little doubt that all the forms which are here placed in the family *Amplexoporidæ* and other allied forms are not *Bryozoa*. Any form which increases by fissiparity or by coenenchymal gemmation, must of necessity be considered as a coral." Numerous extracts of the discussions of Nicholson, Waagen and Koch, as well as the last investigator's observations on the various forms of gemmation and fissiparity are given in order to enable the student to form his own opinion on the systematic position of the monticuliporoids.

It is much to be hoped that the accomplished pelæontologists of the survey of the state of New York will continue in their fruitful endeavors for the students of palæontology. R. R.

Description géologique de Java et Madoura, par Dr. R. D. M. Verbeek et R. Fennema, Ingénieurs en chef des mines des Indes Neerlandaises. Two vols., royal octavo, and a geological atlas, Amsterdam,

1896. This work, begun in 1881 under Verbeek, has been prosecuted, with interruptions, till 1896, including the time required for publication, and in the meantime several other geologists have assisted, and several other important enterprises have been completed, the most important being, perhaps, the exploration of the volcano Krakatoa after the memorable eruption of August, 1883.

The geologic range of the rocks described, belonging to Java, is from certain ancient schists, seen at the islands Karimoun diawa, whose age is undetermined but earlier than the Carboniferous, to the Tertiary and the modern. There is, however, a great interval from the oldest schists to the Cretaceous, unrepresented by any geologic formation. The following table expresses the percentage of superficies occupied by the various rocks.

	per cent.	
The oldest schists (only at Karimoun diawa)	0.046	1.157
Cretaceous, including eruptive rocks (gabbro, diabase, quartzose porphyryte)	0.125	
Eocene, including eruptives	0.232	
Oligocene, including eruptives	0.004	
The oldest andesyte and basalt	0.723	
Neo-Tertiary M_1	14.419	37.752
Neo-Tertiary M_2	13.526	
Neo-Tertiary M_3	9.807	
Leucitic and phonolitic rocks	1.590	27.621
Volcanoes	26.031	
Quaternary	21.024	33.470
Modern	12.446	
	100.000	

If all the superficies older than the Miocene, including the eruptive rocks at the base of the Miocene, be grouped together, they constitute therefore, as remarked by the authors, only one per cent. of the surface of Java; the Miocene forms 38 per cent.; the volcanic rocks 28 per cent., and the post-Tertiary sediments 33 per cent.

The oldest schist, which is supposed to be of the same age as that which also appears in Sumatra and Borneo, is considered to be either Devonian or Silurian.

The Cretaceous beds are referred to the Senomian, but not with positiveness, there being a scarcity of fossils.

The sediments of the Tertiary and their volcanoes occupy the chief place in the descriptive portions of this work.

One hundred and thirty-one volcanoes are listed by name, ranging from an altitude of 3676 metres to 63 metres, Krakatoa being 822 metres. Of these volcanoes 29 are said to be active, although any one of them is liable to resume activity. The highest volcanoes are, in general, the most active, Krakatoa being however an exception. It had, still. been in repose for 203 years before the eruption of 1883. A moderate estimate of the amount of matter ejected at that time makes at least 18 cubic kilometres. Compared with this the volume of rock ejected by the other much larger volcanoes of Java must have been at least ten times this volume, and probably more than fifty times, in the form of lava streams and sheets and volcanic ash and breccia.

In the case of the volcanoes of great hight the composition of the rock is most uniform. With the exception of five which consist of leucitic and phonolitic rocks, all the others are composed of a pyroxene andesyte and of basalt, with their transitions, and of a little obsidian and pumice as acid products. The basic rocks sometimes contain hornblende but very rarely become true hornblende andesytes. The pyroxene andesytes contain regularly more of hypersthene than of augite, while in the basalts augite displaces hypersthene. "It is worthy of remark that throughout Java the pyroxene andesytes are found conjointly with the basalts, but we were not able to prove in any case that these different products issued from the same crater. On the contrary in most places it is possible to prove with certainty that the pyroxene andesytes, destitute of olivine, and the basalts, rich in olivine, issued unquestionably from different craters." This fact and others mentioned by the authors show that the "volcanoes of Java do not all derive their issue from the same reservoir, but that they are rather openings of separate small foyers which retain lavas in different states of acidity, some basalts, others pyroxene andesytes and still others a mixture of these two or transition rocks. The products of the same crater differ, aside from texture, more or less in a low content of olivine. For example, the central crater of Krakatoa has constantly supplied pyroxene andesyte; the lateral crater, of which the peak of Krakatoa properly speaking forms a part, has supplied basalt."

The authors find that although the island of Java has been the scene of constant eruptive activity from the Eocene to the present there are two periods marked by greater energy. The first coincides with the opening of the Miocene, forming extensive sheets of andesyte, and the second at the close of the Teritary, and prior to the present, therefore in the Quaternary. Then were formed, for the most part, the numerous volcanic summits of Java several of which at the present time rise to 3000 or more metres above the sea. They consist, for the major part, of andesyte and of basalt in the form of slightly coherent materials and of lava flows; and exceptionally also of leucitic and phonolitic rocks, which had already appeared to some extent in the Tertiary.

The authors describe the formation of gravels and levigated powders, derived from these rocks at the shores, and the microscopic remnants of the plagioclase, leucite, augite, magnetite and olivine in the resultant rocks, (Vol., I, p. 68)—a process which is supposed to have taken place widely in the production of the greenstones of the Archean.

Notwithstanding the extent of time and the volume of the Java eruptions the authors do not find the law of Iddings exemplified in the succession of the deposits, but rather such a melange of basalt and andesyte that no general order of acidity is discoverable.

The volumes are illustrated by numerous heliotype landscape scenes, and by eleven plates principally of fossil Foraminifera.

The grand atlas which accompanies the work embraces (1) a large geological map with a scale 1:200,000 in 26 sheets. (2) Synoptical map with a scale 1:500,000 in 2 sheets. (3) 21 sheets of special areas, different scales.

They are photolithographed and printed by Giescke and Devrient, Leipzig, but the work issues from John G. Stemler and Co., Amsterdam, published by order of the governor-general of the Dutch Indies.

N. H. W.

Geology of Polk County [*Iowa*]. By H. F. BAIN. (Iowa Geol. Survey, vol. 7, pp. 263-412, pls. 7-9, 2 maps, 1897.) This county, situated near the centre of the state, is of special interest in that it contains the apex of the Des Moines lobe of the latest drift sheet; and, moreover, here were obtained some of the important data which have been used recently by the members of the Iowa survey, especially Messrs. Calvin and Bain, in their separation and classification of the different drift sheets of the state. At Des Moines, in the southern half of the county, the Kansan drift, the Iowan loess and the Wisconsin drift are all well developed and can be easily separated. There are also some facts indicating the possible presence of a pre-Kansan drift. The three parts of the Pleistocene above mentioned can be separated by three important features; (1) by actual overlie, some sections showing the three present in ascending order as given above; (2) by difference in composition and physical characters: (3) by difference in surface contour. The streams flowing in the older drift surface are approaching maturity, the divides are well marked and the country is well drained, while in the newer drift the streams are young, the divides are not well marked and the country is poorly drained as shown by the numerous swales. The main drainage channels, of which the valley of the Des Moines river is the largest, are shown to have been preglacial, consisting of wide valleys excavated in the Coal Measure strata and later filled in with drift which has not been entirely removed.

The surface rocks below the drift all belong to the Des Moines stage of the Upper Carboniferous. They contain important beds of coal, Polk county being one of the foremost counties of the state as regards coal production. The clays, both Pleistocene and Carboniferous, but chiefly the latter, are used extensively for manufacturing purposes, the most important products being, brick, paving brick and tile. The report is accompanied by two maps, one showing the Pleistocene and Recent and the other the pre-Pleistocene geology. U. S. G.

Eine Torfmoor untersuchung aus dem nördlichen Nerike, von RUTGER SERNANDER und KNUT KJELLMARK. (Geol. Inst. Upsala, No. 4, vol. II, pt. 2, 1895.)

Une travaille archéologique faite dans une tombière au nord de la Néricie, par KNUT KJELLMARK. (Geol. Inst. Upsala, No. 5, vol. III, 1896.)

Some interesting results of the study of peat bogs in Sweden have been made known within the last few years.

Among others is the determination of a series of climatic changes observed through the sensitive barometer of plant distribution. The length of time has been sufficient to allow of the development of varieties in some plants among which may be named the water chesnut (*Trapa natans*) which was an article of food with prehistoric man in Europe.

Another point made out is the great antiquity of man in Europe as deduced from remains of his utensils and weapons found buried in the bogs. Work of this kind was done in Denmark a number of years ago, but it is satisfactory to find the work of the Danes confirmed by investigations made farther north.

Dr. Rutger Sernander has been one of the leaders of this work in Sweden. He has found that the time of the Litorina sea, which was the last marine condition preceding the present elevation of the land in Sweden, had three different phases of climate which he identifies with the periods to which Prof. Blytt of Christiania, Norway, has given the names Atlantic, Sub-boreal and Sub-Atlantic.

The *Atlantic* period which lasted while the Litorina sea had a great extent is distinguished by an insular climate with heavy precipitation, having as a result a rich deposit of mud and peat in the peat bogs. During this period the flora had a more southern character than it has at present.

The *Sub-boreal* period, which changed a great many of the ancient lakes and marshes into abodes for the growth a vegetation loving a dry soil, consisting especially of dense wood with perhaps the moss Hylocomium, in the under vegetation, should have had a dry climate.

Finally the *Sub-Atlantic* period began with very heavy rainfall, and the conditions at this time were well suited to the formation of peat and peat bogs.

After the mild Atlantic period there was a fall of temperature and this is especially shown by the discoveries made at the peat-bogs of Gottersåter, which has enabled us to fix the time of the alteration of the climate at the transition from the Sub-boreal to the Sub-Atlantic period.

It is still very uncertain at what epoch man set foot in Scandinavia, but from the mean of a series of observations it has been proved that man lived in Sweden during the first part of the Litorina period. It is known also that from the age of chipped stone the country has been greatly raised above the level of the sea. Dr. Sernander has shown that the "Atlantic" bed of the peat-mosses, which he refers to the Litorina period are synchronous with the age of stone, and mentions the discovery of a lacustrine dwelling near Hållstad in Ostrogathia.

As bearing upon the question of the age of man in Sweden is the discovery in the peat-bog of Gottersåter of fragments of a clay pot by Mr. Kjellmark. This fragment was ornamented with incised straight lines, and is similar to others in the museum at Stockholm which are of the latest part of the age of polished stone. The fragment was unearthed at a depth of two meters in the bog and was in a lacustrine mud of the Atlantic period and so much anterior to the present time, Mr. Kjellmark estimates (with the concurrence of Mr. Montelius who is in charge of the archæological collections of the state museum in Stockholm) that the age of the fragment is a little more than 2000 years before the Christian Era.*

*In a later estimate based on the recession of the Litorina sea, Mr. Kjellmark gives 5500 years as the period which has elapsed since the burial of this fragment of pottery.

The deposit in the peat-bog at Gottersåter is as follows, beginning at the top:

60 ctm.—Peat formed of Sphagnum. (Sub-Atlantic period.)
35 ctm.—Bed of stumps and mould. (Sub-boreal period.)
125 ctm.—Lacustrine mud (of the Atlantic period).

The fragment of a pot was found in this part of the deposit 2 meters from the surface. The mud represents only a part of the Atlantic period—about half, the rest being marked by the marine clay of the Litorina sea that underlies the whole bog.

These results from Sweden are of interest for comparison with the indications of climate, etc., in geologically recent times that have been found in America. G. F. M.

Notes on the Structure and Development of the Turfmoor "Stormur" in Gestrikland, by GUSTAF HELLSING. (Bull. Geolog. Inst. Upsala, No. 4, vol. II, pt. 2, 1895.) This article describes an exploration of the large peat bog of Stormur near Gefle in Sweden. The examination was made along ditches cut to drain the bog. The bottom of the section shows Joldia marl (perhaps a Leda clay). Then a thickness of about one meter of pond and marsh mud. Then a layer of stumps about one-fifth of a meter (indicating an old forest growth). Then a Carex turf of about one-third to one-fifth of a meter, terminating at the present surface of the bog.

The depth ascertained in this part of the bog is not so great as measurements at other bogs in Sweden have shown, but it gives an epitome of bog-growth in Sweden and tells a story similar to the others.

The growth of this bog began earlier than that above referred to as it is situated only 20 meters above the sea-level. The middle layer of stumps corresponds to that of the bog of Gottersåter, indicating a drier climate than preceded or succeeded this time (the *boreal* period).

The special feature of this investigation is the determination of the diatoms in the deposit by Miss Astred Cleve.

The brackish water and salt water forms are found prevailingly in the lower part of the deposit, and the bed marking the *boreal* period is devoid of diatoms.

These results are interesting as showing how these minute organisms may aid in determinating the prevalence of certain physical and climatic conditions. G. F. M.

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Volcanoes of North America. A reading lesson for students of geography and geology. By I. C. Russell. xiv and 364 pp., 16 pls.; New York, The Macmillan Co., 1897.

CORRESPONDENCE.

The Finland Excursion of the 7th International Congress of Geologists.—On the twenty-first of August over a hundred geologists, representing perhaps fifteen nationalities, met at the capital of the Grand-Duchy of Finland, for a week's excursion in that beautiful country of lakes. Director Sederholm, of the Geological Commission of Finland, had immediate supervision of the excursion and through the week interpreted the geology of the pre-Cambrian crystallines of the mainland.

Drs. Frosterus and Hackman and Baron De Geer expounded the glacial geology during the trip, while Dr. W. Ramsay took charge of the party while on the island of Hogland.

The first day of the excursion was spent in the region immediately to the southwest of Tammersfors, in the neighborhood of Suto, Suoniemi and Mauri. At the two first named localities are exposed the mica-

schists and the porphyritic granite of Sederholm's older Archean or pre-Bothian formations. These rocks cover a large area to the south of Tammersfors and extend in an east and west line from lake Paijänne to the gulf of Bothnia. The mica-schist is folded but at the localities visited does not show a high degree of metamorphism.

At Mauri occurs a fine exposure of an interesting metamorphic rock, called by Sederholm leptite. This is a fine-grained gneissic conglomerate, rich in feldspar and poor in mica. The mica that is present is largely muscovite. The rock is of a reddish color and while quite gneissic, its original conglomeratic character is by no means obscured. A lamination, which has been considered original crossbedding, is sometimes marked. This leptite is referred to the Bothnian formation.

On the second day the party coasted in large open boats along the east shore of the picturesque lake Näsijärvi. The first landing was made at the point (south of Aitoniemi) where Dr. Sederholm has found remarkable "Archean fossils" in the "Bothnian phyllites." These slaty phyllites are rich in carbon and plainly of sedimentary origin. They bear some curious slipper-shaped markings. The impressions are 3-10cm. in length and 2-3cm in width and are outlined by a depressed rim (weathered out) of an anthracitic character, approaching graphite.

They lie in bands approximately parallel to the slates in which they occur. Sederholm is inclined to consider them of organic and probably of vegetable origin.

Farther to the north, finely exposed on some of the islands of the lake and also upon the east shore, is the conglomerate schist (Bothnian age) which bears such plain evidence of clastic origin.

This conglomerate, together with other ancient sediments, Sederholm separates by two important formations and three great discordances from the Cambrian, and asks if there may not be in the underlying crystalline complex genuine sediments, which are of approximately the same age as the granites and gneisses of the complex.

In answering the question affirmatively he does not accept the distinction which has been made in America between the Archæan and Algonkian.

This clastic schist is of a conspicuously conglomeratic character, with vertical bedding (?) and a thickness in same cases of 300 m. The pebbles vary in size from 5 m. in diameter to microscopic dimensions. They are oval in form and petrographically are porphyrite, porphyroid, phyllite, leptite and granite fragments. The cement is crystalline but composed of clastic fragments of the same material as the pebbles, associated with secondary minerals (feldspar, quartz and biotite). Interbedded with this conglomerate are basic tuffs and porphyroids.

The most interesting observations of the third day were made in the railway cuts south of Orivesi. Here occur contacts between the Tammersfors schists (Bothnian) and two granites. The granites are distinguished only by the occurrence of porphyritic crystals in the one case and their absence in the other. The discussion turned on the com-

parative ages of the granites and the Bothnian schists. In this question is concerned the age of a large area of granite to the south.

Sederholm considers that the contact between the porphyritic granite and the schists is a mechanical one and that this granite is older than the schist, which includes some fragments of it. While the contact of the schist and the non-porphyritic granite he considers intrusive and this granite younger than the schist.

To many of the party the contact in both cases appeared to be of an intrusive character, and the non-porphyritic granite to be a facies of the porphyritic granite and not to be distinguished as a separate formation. With this interpretation both granites are younger than the schist.

Two following days were devoted to glacial geology and to banqueting.

The åsar of Finland are striking physiographic features. The ås of Tammersfors, the ås of the church of Kangsala and the Kaiser ås were visited by the party. These long, narrow ridges constitute the "mountains" of Finland and from their summits the views are always beautiful. They are interpreted as formed by the retreating delta of glacial streams. Remarkably fine examples of rock scouring and striations occur abundantly in Finland and on the island of Hogland.

The last day of the excursion was spent upon the island of Hogland. This rocky island, in the middle of the gulf of Finland, is about 11 km. long and from 1½ to 3 km. wide.

The interest of the island lies in the fact that it presents in epitome the larger number of the various formations which constitute the mainland of Finland.

The highest land (158 m. high) and the greater part of the island is composed of quartz-porphyry, corresponding in age to the Rapakivi granite of the mainland. (Jatnian or Algonkian). The other formations of the island are all older and are as follows, in order of age from the oldest upward. (1) crystalline schists (Archæan). These schists are impregnated with granitic injections. (2) an uralitized gabbro, showing evidences of dynamic action. The intrusive granite of the crystalline schists, is also intrusive in the gabbro but not in the overlying formations. (3) A quartzite and eurite, which are free from granite intrusions, are subsequent to these intrusions and are thus separated by a discordance from the gabbros. They, unlike the more ancient schists, still show a clastic structure, associated, however, with metamorphic minerals.

These quartzites are, in turn, overlaid discordantly by (4) a basal conglomerate formed of pebbles of the quartzite. A finer grained quartzite is contemporaneous with this conglomerate. (5) In contact with this younger quartzite, which is then altered to a hornstone, and with the conglomerate, which is sometimes caught up into the overlying rock, is an effusive of great petrographical interest and beauty. It has been called a labrador-porphyrite. It is a dark green fine-grained rock with slender lath-shaped phenocrysts of a light colored twinned feldspar. The phenocrysts exhibit a conspicuously trachytic

structure in the hand specimen. Considerable epidote has been developed. This effusive is accompanied by beds of tuff. The youngest formation of the island, the quartz-porphyry, includes fragments of the labrador-porphyrite and the other rocks. It is sometimes microgranitic in structure but becomes felsitic and even vitreous in contact with the older rocks. Like the other formations, it has been subjected to movement, which is shown by a line of friction breccia along the east coast of the island.

The formations of Hogland are thus pre-Cambrian in age and separated by two discordances into three groups. The geology of the island has been worked out by Dr. Ramsay and to him the geologists were indebted for a delightful and profitable day.

Finland presents many of the problems of pre-Cambrian geology which are under discussion in America. Dr. Sederholm has just (August) brought out a brochure, which appears in the form of a Bulletin of the Geological Commission of Finland, on "The Archæan Sedimentary Formations of Southwestern Finland." In this brochure is discussed the petrographical character of the formations.

It is to be followed by a second brochure in which the age of these pre-Cambrian sediments is treated. This will be anticipated with interest by the American students of Pre-Cambrian rocks.

One of the pleasant features of a trip that was full of pleasure and profit, was the cordial good will and most generous hospitality manifested toward the visiting geologists by the citizens of Finland. Both public and private hospitality were shown the geologists with lavish generosity.

At the opening banquet of the excursion, given to the geologists by the citizens of Helsingfors, Senator Mechelin, Prof. Hjelt (Proctor of the University of Helsingfors) and Baron von Willebrand welcomed the guests. Responses were made by M. Barrois, M. Vellain, M. Costin-Vellea, Prof. Brögger, Prof. Cohen, Prof. Iddings and Dr. Sederholm.

That the Finland excursion was remarkably successful in every particular is due to the untiring efforts of the able guides, Drs. J. J. Sederholm and Wilhelm Ramsay.

St. Petersbourg. F. B.

[NOTE.—In the foregoing excursion the following American geologists participated: Bascom, Daly, Emerson, Hobbs, Iddings, Neat, Penfield, Pirsson: the total number being 115. Ed.]

PERSONAL AND SCIENTIFIC NEWS.

WEST VIRGINIA GEOLOGICAL SURVEY. At the last meeting of the legislature a bill was passed providing for a geological survey of the state. The survey was put under a board composed or the governor of the state, the state treasurer, the president of the State University, the president of the State Board of Agriculture and the director of the West Virginia Agricultural Experiment Station. This board held its first

meeting on September 23rd, and effected an organization. Gov. G. W. Atkinson, who is reported as being very enthusiastic in regard to the survey, was elected president of the board and the following officers of the survey were appointed: superintendent, Dr. I. C. White, one of the editors of this journal; first assistant geologist and curator of the collections, Mr. S. B. Brown, professor of geology in the State University; superintendent of the biological division, Mr. J. S. Stewart, director of the West Virginia Agricultural Station; executive officer, Dr. J. H. Raymond, president of the State University. The headquarters of the survey are at Morgantown at the State University. One of the first pieces of work to be undertaken is the preparation, by Prof. S. B. Brown, of a list and synopsis of all publications relating to the geology and biology of West Virginia.

THE GEOLOGICAL SOCIETY OF AMERICA will hold its tenth annual winter meeting at McGill University, in the city of Montreal, on December 29, 30, and 31, 1897.

UNIVERSITY OF MINNESOTA. Prof. C. W. Hall, who holds the chair of geology and mineralogy, has been granted leave of absence for the present academic year. The department is left in charge of Dr. C. P. Berkey who has been for several years instructor in mineralogy; the work in general geology is conducted by Dr. U. S. Grant and that in paleontology by Dr. F. W. Sardeson.

DR. HANS REUSCH, director of the geological survey of Norway, has secured leave of absence from his home duties to accept an appointment for 1897-98 to the Sturgis-Hooper professorship of geology, Harvard University, left vacant since the death of professor J. D. Whitney, a year ago. He will lecture on vulcanism during the first half year, treating volcanoes and eruptive rocks in general; earthquakes and the movements of the earth's crust. In the second half-year, he will lecture on the geology of northern Europe, and its relation to general geology. The third hour of each week will be given to seminary work with advanced students. In the spring, professor Reusch proposes to take part in instruction in the field.

MESSRS. SCHUCHERT AND WHITE, of the United States National Museum, returned from the late Peary expedition to Greenland after visiting most of the known plant-bearing localities of the Cretaceous and Miocene. They spent 28 days in Greenland and in that interval also made a whale-boat journey of 150 miles in order to reach the various important plant localities.

These plants are chiefly interesting from the fact that although above the Artic circle they are of a semi-tropical na-

ture. Their preservation is, however, below the average, and the value of the fossil remains has apparently been overestimated. Heer, who had the advantage of many collections and especially those of Steenstrup, has very thoroughly studied them, and there appears to remain but little to be done in that direction. On the other hand the stratigraphy of the Cretaceous beds of the Noursoak peninsula is not well known, as well as the nature of the invertebrates associated with the fossil plants. It is believed that in these respects the late expedition will contribute a valuable addition to Arctic geology. Of the invertebrates an important collection was made, larger probably than that of de Loriol which formed the basis of his preliminary report to Heer.

The collection of plants, however, will have its chief value in affording a direct comparison between the Cretaceous flora of Greenland and that of America.

The Baffin Land party of the same expedition rediscovered Hall's Ordovician (Trenton) locality "Silliman's Fossil Mount." The specimens are well preserved and will be studied by Mr. Schuchert.

New York Academy of Sciences, Section of Geology. October 18th, 1897. The first meeting of the Academy for the autumn was largely devoted to accounts by various members of the scientific meetings of interest held during the summer. President Stevenson spoke briefly of the work of the International Congress of Geologists at St. Petersburg; the secretary spoke of the work of the geographical section of the British Association for the Advancement of Science at Toronto, and professor Martin gave a similar account of the work of the geological section of the same meeting. The principal paper of the evening, apart from these descriptions, was by Mr. Charles Bullman, who gave a descriptive account of the location and character of the auriferous gravels of the state of Columbia, illustrated by many specimens. In the opinion of the speaker, the auriferous gravels are of wide distribution and thickness, and of exceeding value, and much more extensively distributed than stated by Mr. F. C. Nicholas, who gave a paper before the Academy on the same topic at one of the spring meetings. The speaker believed that the gold deposits are still being laid down in considerable richness and that the whole area around the San Juan river is extremely rich in auriferous deposits. The paper was discussed by Mr. Nicholas, who reiterated his statements, that the gold-bearing clay deposits are not as extensive as they at first may seem to be, and that they are restricted to a few small localities now being dissected and drained by small streams.

Richard E. Dodge, *Secretary.*

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GEOLOGY OF THE ST. CROIX DALLES.*

By CHARLES P. BERKEY, Minneapolis.

Introduction.

The area described in this paper covers sixty square miles. It is ten miles long, north and south, and six miles wide. The St. Croix river flows through the district from north to south, dividing it into two unequal tracts. The portion on the west side of the river, comprising approximately twenty square miles, lies within the state of Minnesota; the eastern portion, approximately forty square miles in extent, belongs to the state of Wisconsin. The meridian of 92° 40′ longitude west from Greenwich and the parallel of 45° 25′ north latitude, pass through the district. The north line of town 34 forms the northern boundary, and the line between ranges 18 and 19 west of the fourth principal meridian passes lengthwise through the middle of the area. The villages of Taylor's Falls in Minnesota, and St. Croix Falls in Wisconsin, are centrally situated.

The southwestern extension of the Keweenawan copper-bearing rocks presents numerous outcrops at this point, and their erosion by the St. Croix river forms the well-known "Dalles of the St. Croix." On account of this prominent natural feature, the district has been called the *St. Croix Dalles Area.*

*A thesis accepted by the faculty of the University of Minnesota for the degree of Doctor of Philosophy, June, 1897.

SYNOPSIS.

PART I. *Geology.*

CHAPTER I. Topography and Special Surface Features.

1. Topographic description of the district, the elevation of prominent points, explanation of accompanying maps.
2. Surface features as modified by lakes, springs, abandoned river channels, river terraces, creeks and the smaller streams.

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1. Summarized statement of local geology.
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CHAPTER II. Lithology of the Igneous Rocks.
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Part I.—GEOLOGY.

(Plates XX, XXI and XXII.)

Chapter I. *Topography and Special Surface Features.*

Topography. The elevation of each of the points established as a basis for the topographic map of the district studied was obtained by aneroid barometer readings. Published altitudes above mean sea level, determined by the surveys of the Saint Paul and Duluth and the Minneapolis, Saint Paul and Sault Ste. Marie railways, were used as primary stations. The existence of one road on each side of the river gave ample opportunity for correction of readings. About 900 aneroid readings were recorded and perhaps as many more taken at intermediate points and used for immediate correction of contour lines in the field. The following points were used as primary stations:

Taylor's Falls depot	791	feet
Taylor's Falls freight house	750	"
Franconia station	915	"
Steamboat landing at Taylor's Falls	687	"
St. Croix Falls depot	920	"
Summit of grade	1010	"
Dresser Junction	950	"
Osceola station	806	"

The following additional points have been selected from the list of those determined by aneroid readings, as representing different parts of the area:

Highest diabase knob—Taylor's Falls, S.W. ¼, N. W. ¼, S. E. ¼, Sec. 25, T. 34 N.. R. 19 W	1040	feet
Colby lake, Sec. 23, T. 34 N., R. 19 W.	940	"
Cemetery, Sec. 24, T. 34 N., R. 19 W	960	"
Residence of Senator Deedon, Sec. 13, T. 34 N., R. 19 W	1100	"
School house, Sec. 11, T. 34 N., R. 19 W	980	"
Diabase knob, N. E. ¼, N. E. ¼, Sec. 1, T. 34 N. R. 19 W	1120	"
Rock lake, Sec. 4, T. 34 N., R. 18 W	1025	"
Trout mere, Sec. 6, T. 34 N., R. 18 W	920	"
Fair grounds, Sec. 20, T. 34 N., R. 18 W	1025	"
Summit of morainic ridge, Sec. 21, T. 34 N., R. 18 W.	1215	"
Summit of morainic ridge, Sec. 6, T. 33 N., R. 18 W.	1165	"
Poplar lake, Sec. 4, T. 33, R. 18 W	1135	"
East lake, Sec. 16 and 21, T. 33, R. 18 W	940	"
Trout mere, Sec. 14, T. 33, R. 18 W	835	"

Picnic ground, Taylor's Falls	905 feet
Public school building, Taylor's Falls	900 "
Toll bridge, Taylor's Falls	725 "

The different topographic features are clearly displayed on the accompanying maps. The different surface features in their geological bearings are elsewhere discussed. It should be noted here that the morainic ridge and accompanying eastern plateau constitute the most elevated portion of the district. These attain an elevation of 1215 feet. The till plains, stretching through the western part of the district and from Dresser Junction southwestward, lie at an average elevation of 925 feet. The river gorge is an abrupt descent of more than 200 feet. Thus the difference in elevation of different parts of the area amounts to more than 500 feet.

Next to the glacial drift, the most potent factors in determining the topographic modifications of the surface features are the bold ridges of igneous rock.

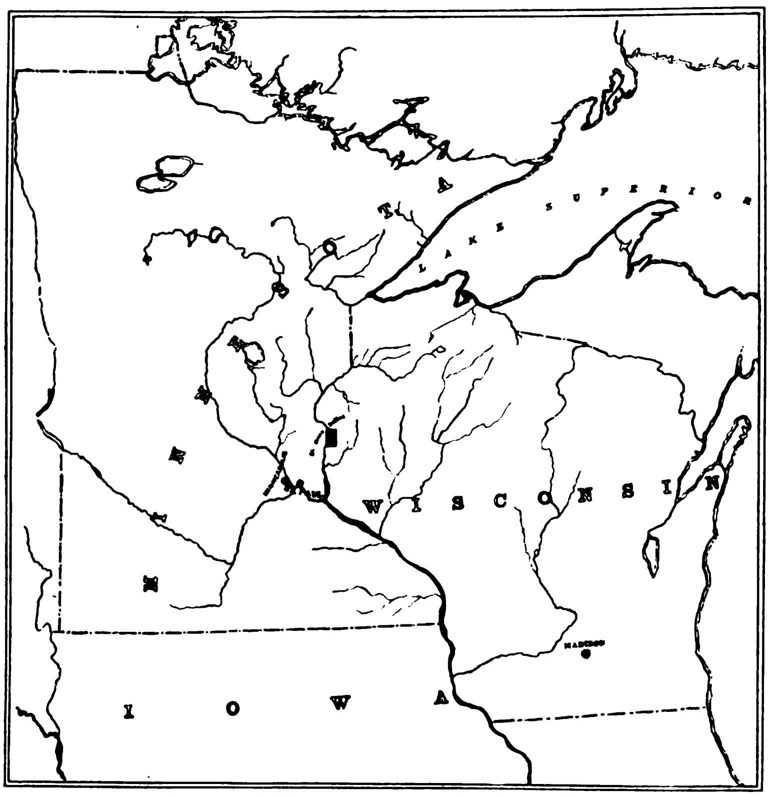

FIG. 1—OUTLINE MAP LOCATING THE ST. CROIX DALLES AREA.

Maps. Two maps have been drawn in illustration of the topography and geology of the area. The first includes the whole district of sixty square miles (see Plate XX, map No. I) while the other, comprising four square miles and including the greater part of the villages of Taylor's Falls and St. Croix Falls, represents the immediate vicinity of the Upper Dalles on an enlarged scale and with greater accuracy of detail (see Plate XXI, map No. II). Figure 1 is an outline map representing the location of the *Saint Croix Dalles Area.*

Lakes. The lakes occurring in the district are of two kinds: 1st, Glacial lakes; 2d, River lakes. In the first class there are two minor groups:

1st. Those which occupy many of the larger kettles of the glacial moraine which borders the northern and eastern sides of the district. These lakes* partly fill the larger and more favorably situated of the numerous depressions of the moraine and are doubtless much less abundant now than formerly. Many of the kettles may be seen in crossing the moraine at almost any point. Most of these lakes have no outlet, although it is probably these very lakes that feed so constantly the springs along the river banks nearly 500 feet lower down. The largest of these lakes are East lake, Poplar lake and Rock lake. All show a gradual subsidence.

2d. Those which remain from the rather extensive marshes or sloughs of the belt of till occupying a part of T. 34 N., R. 19 W. These lakes are now very shallow, and compared with their former extent, have almost disappeared. They once had outlet to the St. Croix river across the flat meadow land stretching northward and southward, but at the present time they are stagnant and muddy. Colby lake, with the four or five small lakes near it, are the representatives of this class.

Under River lakes have been included those now occupying abandoned channels of the St. Croix river. All of these lakes lie close to the present channel of the river, and most of them are directly connected with it and lie at the same level. The most prominent one is Thaxter lake in Sec. 36, T. 34 N., R. 19 W. It occupies a portion of the channel worn by a part of the river previous to the formation of the 750-foot terrace. A small swampy pond not deserving of the name of lake is

*Geology of Wisconsin, vol. III, 1880, p. 374.

found also in Sec. 36, occupying the rocky bed of the old channel used at the time of the formation of the 810-foot terrace. At this same time the erosion at the foot of the rapids following what now constitutes a rock-bound ravine or valley through the northern part of Sec. 1, T. 33 N., R. 19 W., was sufficient to form the basin now occupied by Folsom lake. The river lakes lying in sections 10, 11, 14 and 15 are probably of more recent origin, but date back at least to a time when the volume of water in the St. Croix river was much greater and the channel at this point much wider than at present. The igneous rocks, reaching the river at this place, introduced an obstacle to further erosion of the eastern portion of the channel, while the subsequent accumulation of river sand has barred off this chain of lakes.

Springs. The number of springs,* especially along the river, is very great. There are a few also farther back at either side of the river at a greater elevation. Those issuing at a low elevation along the river may be called river bluff springs; those issuing from the drift at a comparatively high elevation may in contrast be called drift springs.

The river bluff springs are almost without exception confined to the upper Dresbach shales and sandstones, below the 800-foot contour line. They owe their existence to the presence of the river gorge, which makes it possible for the saturated glacial sands and Cambrian sandstones to discharge the surplus water at the level of the more impervious shales and igneous outcrops. Locally, these sedimentaries are completely covered by recent debris of the river bluffs, but their true relations can scarcely be mistaken. At such points the springs seemingly issue from the glacial drift, but the drift in no case causes the flow. These springs are found continuously along the bluffs on both sides of the river. The most remarkable ones issue from the wooded slope lying between the 750-foot and the 810-foot terraces on the Wisconsin side of the St. Croix river in the village of St. Croix Falls. One also occurs in Taylor's Falls village at the same level. To these should be added the Franconia springs, which are the chief supply of Lawrence creek.

The glacial drift springs are all above the 800-foot contour

*Geology of Wisconsin, vol. III, 1880, p. 374.

line and most of them above the 900-foot line. They issue from drift areas, because of local impervious layers which check the underground escape of the descending waters. While such springs are numerous in Wisconsin, there are few on the Minnesota side of the river. The most notable examples are found in Sec. 7, T. 34 N., R. 18 W., where one of the number issues at an elevation of 1,000 feet. It is the water from these springs which is so much used in the maintenance of the several trout ponds or farms located within the district. The three now developed are in Sec. 6, T. 34 N., R. 18 W., Sec. 24, T. 34 N., R. 19 W., and in Sec. 14, T. 33 N., R. 19 W.

The water discharged from the springs of the district is, in most cases, exceptionally clear and wholesome. In a few places along the river much calcium carbonate is deposited from these waters in the form of travertine and crystallized calcite. In a few places iron is carried in considerable amount, and still more rarely, on account of local accidental contamination, the water is too impure for domestic use. But these are exceptional conditions.

Abandoned River Channels. There are several well-marked abandoned channels along the present course of the river. Two of these are referred to under the heading of terraces, but each will here be mentioned and their location noted:

1. The sandy bottom on which the wagon road runs through Sec. 2, T. 34 N., R. 19 W., on the west side of the river, appears to be a part of the ancient river bed, representing a stage marked farther to the south by a well developed terrace. This portion of the channel is separated from the main river gorge by a moderate rise of sufficient elevation to form a considerable island in the river during that stage.

2. The next attempt at cutting a channel outside the present one is found in sections 24 and 25 of T. 34 N., R. 19 W. This is in the northern part of the village of Taylor's Falls. The exact location is in the S. E. ¼ S. E. ¼ Sec. 24, and continuing through the E. ½ N. E. ¼ Sec. 25. This marks a stage coincident with the 780-foot terrace, and is in itself cut down nearly to the 760-foot contour line. At this stage of the river the rock outcrop lying in the S. W. ¼ S. W. ¼ Sec. 19., T. 34 N., R. 18 W., formed a bare, rocky island in the stream, reaching an elevation of 800 feet.

3. The third channel, and the most extensive and important one within the limits of the district, extends from the elbow in the Dalles, S. W. ¼ S. W. ¼ Sec. 30, T. 34 N., R. 18 W., through the W. ½ N. W. ¼ Sec. 31, T. 34 N., R. 18 W., and S. E. ¼ Sec. 36, T. 34 W., R. 19 W., to the river at Folsom lake in N. W. ¼ Sec. 1, T. 33 N., R. 19 W.

It extends slightly beyond these bounds at several places, but not to a considerable distance. The valley is entirely rock-bound, the erosion of which was checked at the 800-foot line. This abandoned channel is in places an eighth of a mile wide. Moses Strong mentions this depression* as probably an abandoned channel of the river St. Croix. There were two prominent rocky islands between it and the main channel at this stage. The first is now represented by the cliff south of the elbow, and the other is the prominent rocky hill in the middle of the S. ½ of Sec. 36, T. 34 N., R. 19 W. This channel marks the stage corresponding to the 810-foot terrace.

4. As the river cut its way into the rocks and sank below the level of the last named channel, the water plunging through the gap at the elbow formed a great whirlpool more than an eighth of a mile in diameter, which is still marked by the great bowl at the head of Thaxter lake in N. W. ¼ Sec. 31, T. 34 N., R. 18 W. The water from this whirlpool reached the main river again by way of the broad, easy channel, the fourth in the series of river channels, the course of which is now occupied by the river-lake, Thaxter, lying chiefly in N. E. ¼ Sec. 36, T. 34 N., R. 19 W. This, with the exception of the pot holes of the Dalles, is the most striking feature of the St. Croix river erosion.

5. The river-lakes lying immediately in contact with the river from Sec. 11 to Sec. 22 of T. 33 N., R. 19 W., represent a part of the channel of the older St. Croix river, which is now almost wholly abandoned.

6. There is a well marked, although not a deeply or evenly eroded valley, extending through sections 1, 12, 11, 14 and 23 of T. 33 N., R. 19 W., passing beyond the limits of the district and terminating in the very prominent abandoned gorge which separates the picnic ground and Eagle Point from the main river channel at Osceola. It is almost continuously divided from the present river gorge by a ridge from 20 to 75 feet high. The average elevation of the floor of this valley is 850 feet. This possibly represents an abandoned channel of the St. Croix at an early stage and probably during the time of a local glacial readjustment. Its persistence, almost parallel with the river for a distance of more than five miles, is the greatest evidence presented in favor of regarding it as an abandoned channel. It marks a stage corresponding to the development of the highest terrace noted near Stillwater, and the 905-foot terrace at Taylor's Falls commonly known as the picnic ground: and its later history, represented by the entire abandonment of that channel, is still marked by the 865-foot terrace of Upham.†

River Terraces. There are five river terraces within the boundaries of this district, marking stages in the erosion of the St. Croix valley. They are all well marked within the two villages, St. Croix Falls and Taylor's Falls. These terraces have been determined by various readings as:

*Geology of Wisconsin, vol. III, 1880, p. 416.

†Geol. and Nat. Hist. Surv. of Minn., Final Rep. vol. II., 1888, p. 417.

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*Geology of Wisconsin, vol. III, 1880, p. 416.

†Geol. and Nat. Hist. Surv. of Minn., Final Rep. vol. II., 1888, p. 417.

20 miles south of this district, two prominent terraces with several minor ones are described.* The lowest of these is 70 feet above the river. The river level is 672 feet above the sea,† making the elevation of the terrace 742 feet. The second of these Hudson terraces is 200 feet above the river, making an elevation of 872 feet above the sea. I do not know of any corresponding terraces in the St. Croix Dalles area, unless we may consider the 905-foot terrace, which is so prominently marked in the village of Taylor's Falls, as such representative. This, I am inclined to think, is a proper correlation. At a time when such a terrace must have been formed it is not probable that any considerable fall was encountered within the distance. It is reasonable to suppose that a descent of 30 feet between the two points would not be excessive for the glacial river. This terrace-like development at 905 feet on both sides of the river is further discussed in the chapter on Glacial Geology.

There is evidently no connection between the 742-foot terrace at Hudson, Wis., and the terraces of this district. It is believed that a considerable fall was developed below the Dalles, where the soft sandstones were reached. If this be accepted, it must also follow that, from the time of their beginning, the terraces above the fall would be entirely independent of those below, not only in the matter of elevation, but also in the point of origin.

There have been two other terraces noted in previous geological reports by Mr. Upham. These extend‡ from Sec. 2 Shaffer northward and are very pronounced terraces. Mr. Upham estimated them respectively 90 and 125 feet above the river. These estimates would indicate at this point elevations of 830 and 865 feet above sea level. It is therefore probable that the first one of Mr. Upham's terraces corresponds to the 810-foot terrace of the Dalles district. The 865-foot terrace has no corresponding development in the 10 miles immediately south of it, unless the 850-foot side channel mentioned before may be related to this stage of the St. Croix river.

The smaller streams and their erosion effects. There are

*Geology of Wisconsin, vol. IV, 1882, p. 134.

†U. S. G. S., Bulletin 72.

‡Minn. Geol. and Nat. Hist. Survey, vol. II., Final Rep., 1882, p. 417.

numerous small streams in this area, the largest being utilized for water power for several manufacturing establishments. Most of them originate in the springs issuing from the river bluffs and flow at once to the river, only a few rods away. Their erosion effects are not very pronounced in any single case, although the combined effect is to remove a comparatively large amount of rock material. Those streams which originate in the springs located in the drift hills, or in similar situation, have eroded quite extensive gorges and frequently exhibit exceptional exposures of the underlying sedimentary rocks. Several streams whose entire supply of water in dry seasons comes from the springs along their courses are in wet seasons the outlets of the lakes of the district. The most notable of these streams are:

1. Rock creek, originating in the morainic lakes near the northeast corner of the area, and following a glacial valley to the river.
2. Dresser creek, following the old glacial overflow plain from near Dresser Junction to the river.
3. Brown creek, originating in the sloughs north of Colby lake and following a tortuous course to the river in Sec. 2, T. 34 N., R. 19 W.
4. Lawrence creek, situated in the western portion of the district, the most notable one, on account of the gorge it has cut through the sandstones at Franconia. During part of the year it is dry in a portion of its course, but the springs originating at the head of the gorge always furnish a considerable flow of water in its lower course. Its erosion effects are entirely disproportionate to the present size of the stream. This creek is the natural drainage for many of the sloughs, which were once lakes of considerable size on the flat till plain lying in the western part and even beyond the bounds of this district. It, no doubt, had a much greater volume of water at that time. The effect of this stream has been to cut a fine gorge from the river at Franconia along the line between sections 2 and 3 of T. 33 N., R. 19 W., for more than one-half mile in length and to a depth of from 150 to 200 feet below the surrounding surface. No such erosion is elsewhere to be found outside the St. Croix gorge itself.

CHAPTER II. *Glacial Geology.*

I. *The Glacial Drift.* Most parts of the district are heavily covered with drift. The only portions lacking it entirely are the more prominent outcropping ridges of igneous rocks. The parts most thickly covered are the preglacial valleys, and probably the tract now occupied by the moraines at the eastern side of the district. Exact measurements are obtainable in but few places.

Taylor's Falls, ravine road, gray drift, 50 ft., modified drift, 3-5 ft., red drift, 75 ft.

Franconia, Lawrence creek gorge.* yellow drift, 20 ft., modified drift, 50 ft., red drift, 50-75 ft.

Senator Deedon's well, drift, 12-15 ft.

Well, N. E. ¼, S. W. ¼, Sec. 1, T. 33 N., R. 49 W., drift, 17 ft.

St. Croix Falls, 2 blocks E. of toll bridge, red drift, 70 ft.

Sections showing the thickness and character of different beds are represented by figs. 1, 2, 3 and 4, plate XXII.

The northwestern part of St. Croix county, Wisconsin, is covered with glacial drift 40 to 60 feet in thickness in which kettle holes are a common feature.†

The glacial debris lies in flat plains of modified drift, flat sand plains, rolling plains of till and a belt of characteristic morainic hills.

Character. There are two sharply defined kinds of material represented in the drift of this locality. In certain respects this area is especially favorable for the study of these two kinds, which are called the eastern and western drift.‡ They occur in three layers. In most of the sections but one or two of these layers occur. That drawn for Taylor's Falls exhibits all three of them, however, and a correlation of this section with those at other points makes such a division advisable. Of these three layers the upper and lower are similar in character and probably identical in origin; the middle layer is distinct from those above and below, and shows the characters that are ascribed to the western drift. For the area on the west side of the St. Croix and a large part of the southern portion of the district on the east side of the river, the prevailing downward succession in the drift is: first, a rather thick surface sheet of western blue or gray till; second, a variable layer of modified drift; third, red eastern drift lying upon the eroded preglacial rock surface. In the northern and eastern portions of the district, especially those portions lying north and east of the village of St. Croix Falls, the prevailing character is that of the eastern drift. No exposure seen shows any of the western material. But on the west side of the St. Croix river at Taylor's Falls and, as appears from the relative

*Geol. and Nat. Hist. Survey of Minn., Final Report, II, 1888, p. 412.

†Geology of Wisconsin, vol. IV, 1882, p. 132.

‡Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, 1888, p. 410.

position, also further north, along the high diabase ridge, there is a much more complicated succession. The most complete section is shown at the picnic ground, in Taylor's Falls, and on the side of the drift ridge back of the village.

Upon the lower shales, at an elevation of 770 feet (see fig. 2, plate XXII), rests partially stratified till of characteristically eastern material, which continues uninterruptedly along the ravine, at the side of the street, to an elevation of 845 feet. At the same time the shales are traceable in the same ravine to an elevation from 800 to 825 feet, and then become concealed beneath the debris. A bed of gravel and small boulders about 2 to 3 feet in thickness lies immediately upon this red stratified deposit and separates it from the overlying accumulation of typical western bluish gray material. This western drift is a till in which boulders, pebbles, gravel, sand and clay are promiscuously intermingled, and in which, compared with the lower member, regarded as eastern drift, the presence of numerous limestone boulders and an abundance of calcareous material is the most conspicuous feature. This upper member is not so markedly stratified as is the lower one. On the exposed surface, however, it has a tolerably compact appearance due to the great amount of calcareous material available as a cementing substance. The result is, in some places, a kind of crag. The thickness of this gray and bluish gray drift layer is 35 to 40 feet, reaching an elevation of 885 feet. From this point the character of the material changes somewhat, becoming chiefly sand and gravel with a covering of soil to the top of the bluff, at an altitude of 905 feet. This forms the highest river terrace, which continues westward as a sandy plain for a thousand feet, to the high ridge back of the village. Here, at an elevation of 935 feet, ten hundred and fifty feet east of the Swedish church, a large patch of red till 10 feet in thickness is found exposed. Above this there is sand and gravel to the highest, or 1,100 foot contour line. This red patch is believed to represent a later advance of the eastern ice lobe upon the western drift area, rather than a remnant of an earlier accumulation left unmolested by the western invasion. Additional support is given to this view by a similar exposure of red till occurring on the same ridge farther north, in the S. E. ¼, S. W. ¼, Sec. 13, T. 34 N., R. 19

W., along the road near senator Deedon's farm. (See plate XXII, fig. 1.)

In all essential respects this last named exposure resembles the Taylor's Falls occurrence with the exception that it lies at an elevation of nearly 1,050 feet, or more than 100 feet higher than that. The two miles intervening between the two areas shows continually a sandy modified drift. The drift encountered on the Wisconsin side of the river, along the wagon road eastward from the toll bridge and upon the shales, as shown in plate XXII, fig. 4, is typical eastern till. It is first seen at an elevation of 880 feet and continues to an elevation of 950 feet, where it suffers an interruption preventing further accurate observation. A quarter of a mile further south, on the road in the northern portion of Sec. 31, T. 34 N., R. 18 W., a slight removal of the soil again reveals the red eastern till at an elevation of 1,000 feet. This is regarded as a continuation of the section of eastern till resting upon the sandstones and shales as represented in fig. 3. The western drift has not been observed east of the river at this point. The characters indicating the presence of the eastern drift can be followed still further southward and to a still greater elevation. In the N. E. ¼, N. W. ¼, Sec. 6, T. 33 N., R. 18 W., the road crosses the crest of the ridge. At this place, which is one mile south of the exposure in Sec. 31, red till is again exposed. The elevation at this point is 1,150 feet.

A mile still farther south the road descends into the broad valley near the head of which is Dresser Junction. At that point the drift material changes very noticeably and the characters of western drift predominate in the surface exposures. This is true of the whole valley, although some portions are much more sand covered than others. How far this western aspect extends into the bordering moraine is not determined, but the material observed upon the ridge is of eastern origin, which would seem to limit the western invasion at its western border. It is probable that this extensive moraine was not to any considerable extent developed by the western invasion of the ice sheet. For the continuation of the moraine further northward seems wholly independent of western influence and is composed of eastern material.

Origin and Periods of Accumulation. As to the origin of

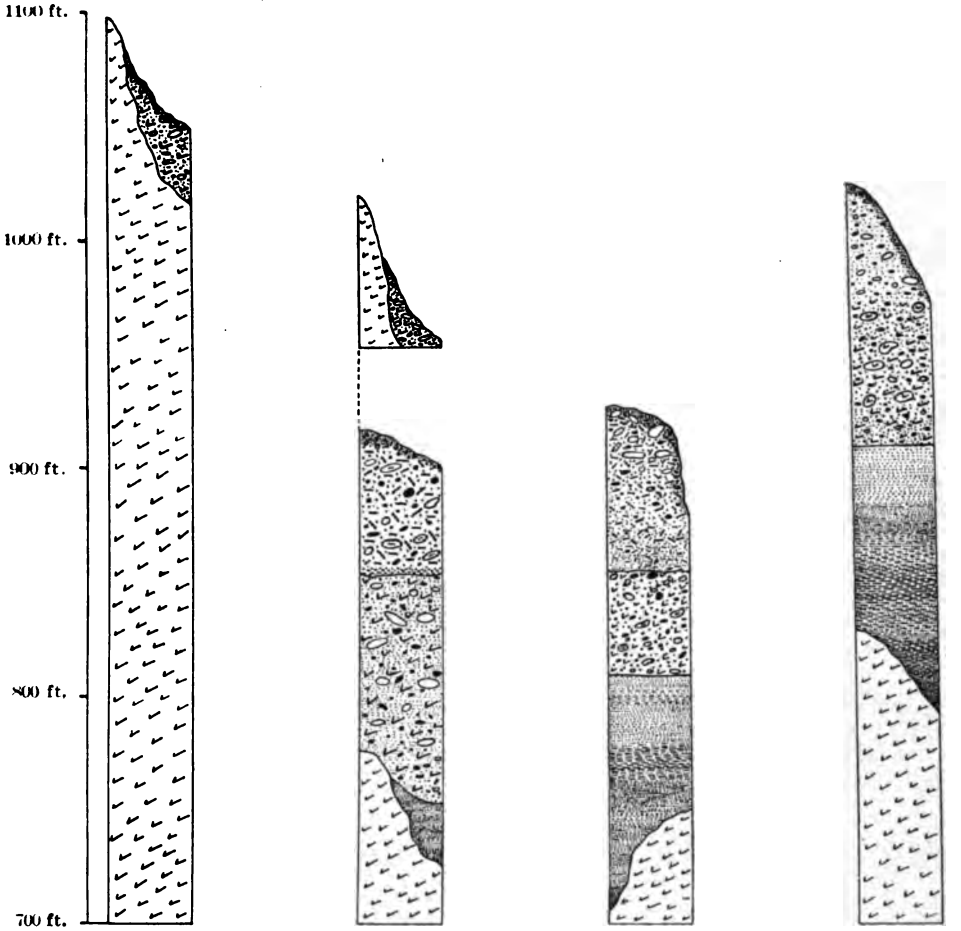


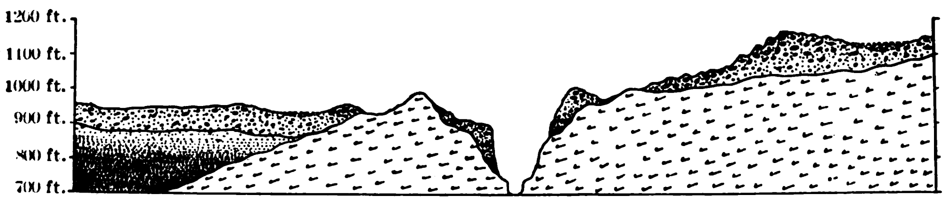
Fig. 1.—Deedon Section. Red drift on the Diabase.

Fig. 2.—Taylor's Falls Section. Red, gray and red drift.

Fig. 3.—Franconia Section. Gray and red drift.

Fig. 4.—St. Croix Falls Section. Red drift on the sandstones

Sections of the Glacial Drift and Underlying Rocks.



Profile of the area along a line drawn through Colby and Poplar lakes, showing Glacial Drift, Cambrian Sedimentaries and Keweenawan Diabases.

the different materials of which the drift is composed, the character of rock from which it was derived, and the source of supply, there is but little variation from observations made by Minnesota and Wisconsin geologists. The following statements are intended to summarize these points:

1st. The eastern drift was derived largely from the igneous and iron-bearing rocks of the Lake Superior basin. The most abundant rock species noticed are: melaphyr (occurring in rather large boulders); granite; amygdaloidal diabase; gabbro; quartz porphyry; diabase porphyrite; together with the sedimentaries, quartzite, red and yellow sandstone and a considerable admixture of highly ferruginous pebbles and fragments. The clayey material is red in color. Sand and gravel are abundant.

2d. The so-called western drift carries many of the same rock species as the eastern. In addition, however, limestone boulders and pebbles are abundant. The till and clay are usually gray or bluish gray in color and contain considerable finely ground calcareous material.

It is evident that two such characteristically different deposits must have been derived from two very different sources. Either the characteristic constituents of the gray drift were exhausted in a certain direction and were therefore of necessity succeeded by a quality very different on account of that lack; or we must suppose that there are at least two different areas of supply furnishing the material by two independent ice streams. The latter view is the more reasonable. In accord with the known character of the rock formations in different directions from this area, the red drift is believed to have come from the north and northeast, while the gray and blue has come from the west and northwest.*

As to the periods of deposition, evidence shows that there were two and perhaps three different periods of accumulation. Whether any of the drift represented here was accumulated earlier than the Iowan stage of re-advance may be doubted. Correlation with subdivisions accepted in other districts is difficult since this is so far removed from typical localities. The time intervals were comparatively short, indeed the ice fronts were, during a part of their duration, in actual contact. The eastern lobe, however, persisted longer than its western companion-lobe, and accumulated the extensive deposits credited to the Wisconsin stage of advance.

The Moraine. The Kettle range of the Wisconsin geologists† includes in many parts of its extent several quite dis-

*Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, 1888, p. 410.

†Geology of Wisconsin, vol. I, 1883, pp. 275-281.

tinct and nearly parallel morainic ridges, which may quite properly be treated as independent moraines.

These ridges or moraines mark the halting places of the glacier in its first stages of retreat after the so-called Wisconsin re-advance. One of them lies within the St. Croix Dalles area and extends throughout its length, from sections 19, 20 and 21, T. 33 N., R. 18 W., to sections 1 and 2, T. 34 N., R. 19 W., coming in its northern development close upon the river in Sec. 2. This is an especially important moraine, not so much because of its relation to the Kettle Range, as because it follows the dividing line between the eastern and western drift. The western material cannot in all places be traced eastward to this morainic ridge, but generally it can be thus traced, and nowhere has the western material been found to the east of this moraine.

The name St. Croix moraine is proposed for this ridge, since it passes in its typical development only a short distance to the east of the village of St. Croix Falls, and follows almost parallel with and at certain points encroaches upon the river St. Croix, and because it apparently marks a stage of ice lobe adjustment and drift accumulation that was the chief factor in causing the St. Croix river to flow in its present channel.

The St. Croix moraine varies in width from one mile to two and a half or even three miles. It is bordered on the east by a high rolling plain extending several miles beyond the district. The moraine is bordered on the west by several valley and plain areas, all of which will average 200 feet lower than the corresponding highest parts of the moraine itself. This ridge is characterized by a very hilly and irregular contour. The surface is alternately a knoll and a kettle or a short ridge and a blind valley. Many of the larger kettles are small lake basins.

Drainage courses are not sharply marked, and many of the lakes have no outlet. Most of the drainage is underground. The kettles sink frequently 100 feet below the lowest possible outflow. The knolls often rise 100 feet above the average level. The whole effect is to produce an almost continuous succession of knobs and ridges which are simply bewildering in any topographic determinations. The materials of the St. Croix mo-

raine are largely sand, gravel and small boulders, and the origin is the same as is that of the red drift.

The Level Tracts. Three well developed plains covered mostly with till, occur partly within and partly without the St. Croix Dalles area. These will be referred to as the eastern, western and central plains.

The eastern plain extends from the St. Croix moraine eastward for several miles. Only a narrow strip comes within the territory examined, but enough of it has been seen to disclose its prevailing characters. It is rolling or undulating in surface, but does not vary much from the 1,200 foot elevation. There are numerous small lakes and sloughs, and it is an area of excellent farming land,.thickly settled. Its material is a till with characters which belong to the eastern drift.

The western plain lies upon the west side of the St. Croix river. It extends from Franconia station westward and northward, including the whole west central portion of the district. The northeastern boundary is formed by the diabase ridge extending from the village of Taylor's Falls northward. This plain also extends far beyond the bounds of the area. Only occasional irregularities break the prevailingly level contour, varying in elevation from 915 feet at Franconia to 950 feet a few miles further north. It is a till covered area of western drift, the character of which can be studied in many places. The drift on this area* has been noted and approximately mapped by Mr. Upham.

The prominent bench in the village of Taylor's Falls, known as the picnic grounds, is in character of materials intimately connected with the western till plain. The considerable accumulation of sand and other modified drift bounding it on the west does not apparently owe its origin wholly to river action; it is no doubt derived from the adjacent esker-like ridge.

The central plain is a peculiar glacial accumulation situated immediately to the east of the village of St. Croix Falls. It occupies a large part of the S. E. ¼, Sec. 19, and a portion of Sec. 20 adjacent, the N. E. ¼ of Sec. 30 and the adjacent portion of Sec. 29, T. 34 N., R. 18 W. This accumulation is con-

*Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, 1888, p. 412.

nected somewhat brokenly with a prominent level valley averaging a half mile in width, which follows quite closely the boundary line between sections 31 and 32 of the same township. The northern third of this plain, viz., those portions lying in sections 19 and 20, lie at an elevation of from 1,020 to 1,025 feet, and is almost level but somewhat depressed centrally. It drains northward to the St. Croix river. On the west this plain is limited abruptly by the river gorge which is a sharp descent of over 300 feet within a distance of less than half a mile. In most respects this level area resembles a terrace; it also reminds one of the similar development on the opposite side of the river, in Taylor's Falls, known as the picnic ground. But the difference in elevation of the two is more than 100 feet, while the differences in character are equally striking. The St. Croix moraine forms its eastern boundary. Southward it is somewhat broken, but still it shows the same character, and near the south line of Sec. 29 it is too much cut up to be recognized. From this southern portion of the plain a very prominent erosion valley leads toward the N. N. W., and follows its edge for nearly a mile to the railway station in St. Croix Falls. Southward still further, in Secs. 31 and 32, the plain again becomes prominent, this time, however, as a very distinct valley lying between the St. Croix moraine on the east and the high diabase ridge on the west. This level tract narrows rapidly near the south line of Sec. 32, where it merges into a rock bound gorge. The walls of this gorge are precipitous on the west and rise gradually toward the east. The bed of the channel is solid igneous rock. This southern termination of the valley has an elevation of 1,010 feet. From this point southward another area is developed partly as a resultant of the first, but of very different character. All points necessary for decisive conclusions are not at hand. The only ones lending any weight toward conclusions as to origin are the following: The material is of eastern origin; it slopes gradually toward the south and leads to a well marked late glacial river gorge; the western boundary is in part the present river gorge which is, at this place, the limit of the western drift; the eastern boundary is at all times the St. Croix moraine which represents an eastern drift accumulation.

The facts suggest the following statement of conditions obtaining during and immediately preceding the withdrawal of the latest glacial ice lobes at this locality. The western ice lobe advanced spreading the western drift to the very position now occupied by the central plain. Here it was met and energetically opposed by a northeast lobe carrying much debris and rapidly accumulating the thicker eastern drift deposits. The eastern advance was even energetic enough to override the edge of the western lobe, and left a few patches of characteristic material within western territory. With the melting of the ice the two lobes separated and a lake formed on the present site of the plain, which was drained by the development of the channel at its southern extremity.

An early halt in the eastern lobe developed the St. Croix moraine and served to furnish immense floods to the rivers of that time, of which there are traces of at least two more within the district. As the western lobe retired it uncovered an additional line of drainage represented by the present river gorge and the narrow valley extending northward along the railroad to St. Croix Falls station.

The level floor of this narrow erosion valley for a distance of at least a quarter of a mile indicates that at this elevation, 905 feet, deeper water was reached, which effectually checked extensive erosion.

It is important to note in this connection that the Taylor's Falls picnic grounds bench across the river is of the same elevation, and equally level, and equally suggestive in the character of its material of river or lake influence. If it be river influence, they mark the highest prominent river terrace; if it indicate the position of an ice-dammed lake, the fact still remains that such a lake occupied the place of the later river, and upon its subsequent drainage left, as its eastern and western limits, these two terrace-like deposits in evidence of its existence.

The central plain just described is intimately connected with a more extensive tract which may be referred to as the Dresser Junction flood plain.

The rock bound gorge connecting these two plains is clearly a glacial river channel. It broadens into a sand covered valley at an elevation of 965 feet, following closely the west

line of section 5, T. 33 N., R. 18 W. The valley in its southern extension, includes the greater part of sections 7 and 18, T. 33 N, R. 18 W., and sections 13, 14, 23 and 24 of T. 33 N., R. 19 W., and is continued beyond the bounds of the St. Croix Dalles area. Western material is found abundantly strewn among the pebbles around Dresser Junction. The greater portion of the plain is composed of modified drift. This valley seems to mark the farthest advance of the western ice lobe. And, as the ice melted back, it became the course of a river which carried away the later glacial floods. All parts of this valley near the moraine are deeply covered with coarse sand. Farther away from the morainic source of supply the more level stretches of the plain have comparatively good soil. A second tributary to the plain stretches through section 18 and develops into a deep, sandy ravine leading into section 4, toward Poplar lake, which nestles among the morainic hills. Except for the igneous rocks encountered in the former channel, this old drainage course seems to be as important as that, and has no doubt been in more constant use since those conditions which produced them both disappeared.

Rock Creek Valley. The largest stream tributary to the St. Croix in this area, is Rock creek. Rising beyond the boundaries of the district it occupies a deep valley extending westward near the south line of sections 4 and 5, T. 34 N., R. 18 W., and then swings quite abruptly to the southwest through section 7 to the river. It is not wholly a late erosion valley. The kettles and knobs which characterize the moraine extend also into this valley. On either side the knolly ridges rise to 1,100 feet, and toward the north and east they are immediately merged into the plateau, more than 1,200 feet in altitude. The bottom of the valley lies for the greater portion of its extent above the 900-foot contour. Below that line, however, there are abundant erosion phenomena—sand flats, benches and terraces. The extensive level tract in S. E. ¼ of Sec. 7 seems to indicate terracing, and should be correlated with the 905-foot terrace at the Dalles.

A slight bench at 860 feet, along the wagon road, may be the local development of the 865-foot terrace of Upham* described as lying two miles further north.

*Minn. Geol. and Nat. Hist. Survey, Final Report, vol. II, 1888, p. 417.

This 300-foot valley, from one-fourth to one-half a mile wide, extending back among morainic ridges for several miles, and showing undisturbed terminal accumulations almost to the bottom, constitutes a somewhat unique feature in the surface geology of the district. It probably lies in the direction of movement of the latest ice advance, and is partially due to glacier erosion of an older drainage course.

II. Effect of Glacial Action upon Earlier Formations. The glacial action left distinct marks upon both the igneous and the sedimentary rocks. On the diabase the effect is much more easily observed at this time, although the action was very much more effective on the sedimentary rocks. Glacial striæ, smoothing of exposed surfaces, the breaking down of ragged cliffs, fluting and glacier erosion can be seen. All these except the last are more successfully preserved and therefore more readily seen on the igneous outcrops.

Glacial striæ are not found at every outcrop, although one or more of the above mentioned evidences of glacial action are to be seen at any extensive exposure. Those showing striæ most plainly and abundantly with their bearings are the following:

1. N. E. ¼, N. E. ¼, Sec. 1, T. 34 N., R. 19 W.

Near road—few striæ bear S. to S. E.

West side of outcrop—striæ bear almost E. and W., as an average direction. Of the variable ones, the greater number run N. E. and S. W. angle of variation nearly 90 degrees.

Most of the striæ are along the extreme western border of the outcrop. Of those noted the majority had a direction N. of E. to S. of W., between 15 and 20 degrees, a few were found from W. of N. to E. of S. about 20 degrees, and still others were E. and W.

2. S. W. ¼, N. W. ¼, Sec. 6, T. 34 N., R. 18 W.

West slope of outcrop—striæ found only on the smooth, close grained portion of the exposure. They bear E. and W., also N. of W. to S. of E.

3. N. W. ¼, Sec. 5, T. 33, N., R. 18 W.

Markings on the very smooth polished surfaces of the diabases of the old channel from which the soil has been removed by the building of the M. St. P. & S. Ste. M. railway, bear almost N. and S. These markings may have other origin.

4. Sec. 31, T. 34 N. R. 18 W., near the center of the south half of the section, in the public road, are some low, evenly polished exposures of diabase on which markings occur.

5. In the village of Taylor's Falls, near the Swedish church on the highest exposed portion of the igneous rocks, glacial markings may be

seen. The following directions were noted in different places at this locality:

Well preserved striæ bearing N. 25 degrees E., a few other faint marks at an angle of about 45 degrees to these.

Well preserved striæ N. W. to S. E. and several bearing a few degrees more westerly.

Near the church—strongest marks N. 20 degrees E., faint marks exactly N. W. and S. E.

A few more were seen varying at small angles from the directions given above.

Former observers* have noted glacial striæ at the following points:

Sec. 36, T. 35 N., R. 19 W., bearing S. 40 degrees E.

Sec. 29, T. 34 N., R. 18 W., shallow flutings, bearing about S. 45 degrees E.

At Hinckley† the glacial striæ bear S. and S. 5 degrees W.

Very few places show striation of a persistent character, and readily escape observation. At nearly every place the bearing of the striæ is extremely variable, the directions being frequently at right angles to each other, with many intermediate degrees of variation.

The igneous flows dip in general toward the S. W. and W. S. W. This, with the tendency toward columnar structure gave opportunity for extensive destruction of the original cliffs. At such points as developed particular concentration of glacial abrasive action, which would be the case in those valleys lying between two ridges of eruptive rocks, or at a gap in an opposing ridge, the destructive influence should be strongly marked. This influence is especially noticeable at the old glacial channel in Sec. 6, T. 33 N., R. 18 W., and in the village of Taylor's Falls, at the Dalles. The rock exposures above the 800-foot contour, at the last named locality, bear evidence of ice abrasion as a factor in widening this gap between opposite cliffs, while the lower benches exhibit sufficient evidence of water action to explain all the erosion at that point.

On the sandstone and shales the effect of the glacial erosion was almost wholly confined to scooping out valleys between parallel igneous ridges, resulting in the removal of the comparatively soft sandstone to a level from 10 to 300 feet lower than the adjacent crystalline outcrops.

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*Geol. of Wisconsin, vol. III, 1883, p. 382.

†Warren Upham, Geol. and Nat. Hist. Survey Minn., Final Rep., vol. II, 1888, p. 642.

The localities illustrating this erosion are so numerous that it is scarcely necessary to do more than call attention to the map of the district. The most important example is that of the valley now partially occupied by the St. Croix river above the Dallès. The stream lies for nearly five miles almost without a break, between parallel ridges of diabase, standing, on an average, one mile apart and reaching an elevation of from 100 to 300 feet above the adjacent sedimentary rocks. This difference of elevation is believed to be due not so much to preglacial land erosion as to the direct action of the ice during the glacial period itself.

The effect of the glacial erosion upon the drainage of this portion of the St Croix valley may be traced to a limited extent. Almost nothing can be claimed to be added to our knowledge of the preglacial St. Croix. The present channel is not believed to represent the original location of the river, although smaller streams may have occupied portions of it. The rock wall which occupied the site of the present Upper Dalles was an effectual dividing ridge, and to the north of this, small streams, occupying the present positions of the St. Croix river and Rock creek drained northward until some river was reached which probably emptied into the Mississippi.* In the southern portion of the district all evidences indicate that the present St. Croix river gorge is postglacial.

The inter-glacial St. Croix, up to the time of the invasion of the western lobe, at the beginning of the Wisconsin epoch, seems to have followed the preglacial drainage lines as understood above. But with the encroachment from the west a new connection with the Mississippi was made, and it at that time followed the extreme front of the invading ice.

The channel at present occupied by the St. Croix river varies but little from that just mentioned. An impracticable early course in the vicinity of Dresser Junction was abandoned. The river fell back finally with the retreat of the ice to its present more favorable course. The chief factor in making the present channel the most available and permanent line of drainage was the glacial erosion accomplished at this locality. There is little doubt but that the considerable bend toward

*Mr. Upham, Report of the Park Com., State Park of the Dalles of the St. Croix, 1897, p. 45.

the east which is continued for a short distance into the northern portion of the area, is chiefly due to the opposition of the ice and its accumulated debris coming from the west. The whole effect of postglacial erosion has been to deepen the chosen course of the stream. Any variation from it is seen solely in the slight shifting from the minor abandoned channels in its later development.

If this be the true explanation of the evidence at hand it argues that the remarkable erosion phenomena, which are so noticeable in the gorge in the vicinity of the Dalles, are all of late glacial and postglacial age, the larger part of which was accomplished at the immediate close of the glacial period during the time that the river served as the overflow channel for the West Superior glacial lakes.*

At this time the volume of water discharged was abundantly sufficient to account for all the erosion phenomena which seem so superior to the amount now carried by the St. Croix river. Chief among these phenomena are the enormous pot holes worn in these rocks at St. Croix Falls and Taylor's Falls.

Summary. The foregoing discussion, dealing with phenomena observed in this district, has a bearing upon some of the questions receiving present attention among northwestern glacialists.

Among these is the question of single sheet as opposed to several independent lobes, the latter of which is more agreeable to accumulating evidence.

The marked variability in the bearing of the glacial striæ, the peculiar character of certain areas of drift accumulation, and the change from a surface drift of western character to one of eastern origin, suggests that the district is one of the critical areas for the study of glacial geology.

Mr. Upham's determination of the northern limit of the blue till† at about the course of Snake river, and its southern limit, through the northern part of Washington county, no doubt accords with the limit noted in this district, and is consistent with the facts presented in this discussion.

Mr. Upham's attempt to correlate the farthest advance into

*Geol. of Wisconsin, vol. I, 1883, p. 286 and p. 261.
Upham, Geol. and Nat. Hist. Survey of Minn., Annual Reports.

†Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, 1888, p. 412.

Wisconsin with the 4th or Kiester moraine,* is not necessarily substantiated by the evidence herein set forth. In fact the morainic development due to western accumulation seems to disappear gradually as it approaches this area.

Wisconsin geologists refer to the Kettle range, of which the moraine immediately east of St. Croix Falls is a part, as probably belonging to the same stage as the accumulation known as the Leaf Hills moraine in Minnesota.† Such correlation is not yet substantiated and can not be so long as the glacial accumulations immediately south and southwest of the extremity of lake Superior are so imperfectly known.

Observations in this district indicate that the erosion of the St. Croix Dalles is post-glacial.

CHAPTER III. *Stratigraphic Geology.*

The exposed sedimentary rocks in the St. Croix Dalles area vary from a few feet to 225 feet in thickness. An equal thickness probably lies below the level of the St. Croix river, upon the very irregular floor formed by the Keweenawan rocks. If the dip of the igneous rocks were constant, however, a thickness of 1,500 to 2,000 feet could be attained along the western margin of the area.

The dip of the several subdivisions is fairly uniform southward at a very gentle inclination, amounting to 50 to 75 feet per mile.‡ While varying slightly at different places, the dip is fairly constant to a considerable distance beyond the bounds of the area. Approaching the district from the south and west, it is noted that the successive members of the Magnesian series disappear one by one until, at Eagle Point, near Osceola village, the Oneota dolomite constitutes the cap and surface formation. Within the bounds of the district this formation also is lacking, and the Jordan sandstone becomes for some distance the uppermost formation. No attempt to follow the subdivisions toward the north beyond Osceola has heretofore been attempted. The subdivisions of the Magnesian series§ recognized at Osceola are, approximately: Oneota

*Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, p. 415.

†Geology of Wisconsin, vol. III, 1880, p. 385.

‡Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, 1888, p. 409.

§The Magnesian Series of the N. W. States, by Hall and Sardeson. Bull. Geol. Soc. of America, vol. 6, 1895, pp. 167-198.

dolomite, 30 feet, Jordan sandstone, 75 feet, St. Lawrence dolomites and shales, 40 feet. At this place the Oneota and Jordan formations are rather sharply separated, as are likewise the Jordan and St. Lawrence; but the lower limit of the St. Lawrence is not prominently marked.

Below the St. Lawrence formation a series of more or less clearly defined beds of sandstone, shales, greensands, calcareous shales, pyritiferous shales and conglomerates has been included by geologists in the terms,—Lower sandstone,* Potsdam sandstone,† St. Croix sandstone,‡ Basal sandstone,§ and Dresbach and Hinckley sandstones.‖ without subdivision. The fauna, which seems largely confined to the lowest shales, was considered too meagre for a satisfactory correlation of the formation, and a discouragement at the outset to any successful subdivision.

Additional Data. Explorations of the writer have brought to light several facts which bear directly upon the question of correlation and subdivision of the lower sedimentary rocks of this district. They are the following:

The existence of a well-marked sandstone conglomerate has been determined; and St. Lawrence shales have been found to occur in Sec. 1, T. 33 N., R. 19 W.

The persistence of certain lithologic characters have been shown.

The discovery has been made of an extensive fauna in the marginal conglomerates.

The Sandstone Conglomerate. Along the wagon road through the N. E. ¼, N. E. ¼, Sec. 1, T. 33 N., R. 19 W., there is exposed, to a limited extent, an interesting conglomerate, of which specimens are readily obtained. The significance of the occurrence lies in the fact that the worn pebbles of this conglomerate are of sandstone, which are enclosed in a matrix of sandstone. The pebbles are little more compact and resistant than the matrix sand itself, are perfectly worn and range

*Owen: Geol. Survey of Wis., Iowa and Minn., 1852.

†Chamberlin: Geol. of Wisconsin, vol. I, 1883, p. 123.

Hall and Sardeson: Bull. Geol. Soc. of America, vol. 3, 1892, pp. 331-368.

‡Upham: Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, 1888, p. 407. Winchell: Final Rep., vol. I, 1884, p. 257.

§Norton: Iowa Geol. Survey, vol. VI, 1897, p. 140.

‖Winchell: Final Rep., vol. II, 1888, p. xxii, and 21st An. Rep. Geol. and Nat. Hist. Survey of Minn., 1892, chart, p. 5.

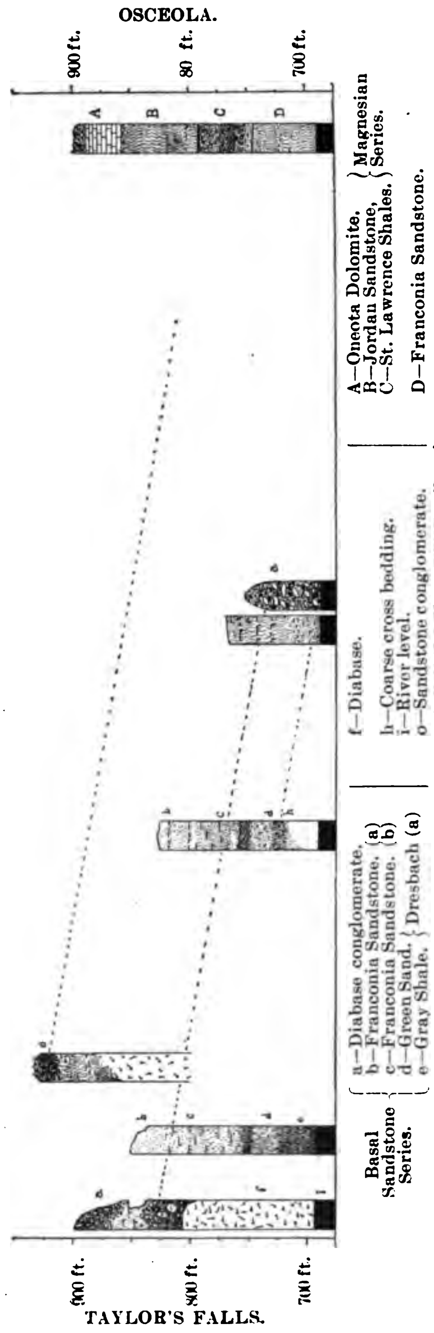

Fig. 2.—Sections of the Sedimentary Rocks.

in size upward to three inches in diameter. They show no fossil content, although the matrix carries abundant fragments of trilobites. An outcrop of igneous rock lies in the immediate vicinity, but the intervening distance between it and the conglomerate is covered by soil and drift. Sandstones and shales are exposed at numerous places along this same road at lower levels, and presumably at lower rock horizons, but a continuous section is not obtainable. The friable nature of sandstones makes them especially liable to mechanical destruction and for this reason a sandstone conglomerate is a rarity among rocks. This circumstance makes the occurrence an interesting one, and the evidence which it gives in support of the view that a considerable erosion interval occurred at this point makes it of additional importance. To what formation the sandstone conglomerate belongs, and what this break in sedimentation may mean are questions which deserve attention.

Fig. 2 was drawn to illustrate this occurrence and to correlate the subdivisions of the Cambrian sedimentaries of this locality. By reference to this chart, it is seen that the average dip of the sedimentary strata, as they appear in the river gorge, makes the sandstone conglomerate correspond to the well known break between the St. Lawrence and the overlying Jordan. Further, this St. Lawrence-Jordan* interruption in the continuity of the strata, is the only one thus far known commensurate with the formation of such a conglomerate. The lithologic characters and faunal content of the matrix are more closely allied to those of the Jordan than to any other formation. For the Jordan is an extensive sandstone formation, characterized by thick, coarse cross-bedding, well agreeing with the abundant supply of material, derived, in part at least, from the destruction of the St. Lawrence and earlier strata. It appears then that this sandstone conglomerate represents the extreme northern limit of the Jordan sandstone, with which it should be correlated: and the time break indicated was great enough to secure a solidification of earlier formations sufficient for the construction of a conglomerate from their debris.

The St. Lawrence Shales. From a well in the S. W. ¼, S. W. ¼, S. W. ¼, Sec. 1, T. 33 N., R. 19 W., were obtained two specimens of a sandy shale which resembles, in lithologic characters, the St. Lawrence shales found at Osceola Falls. This occurrence is 850 feet above sea level, and therefore would agree in altitude with a continuation of the St. Lawrence shales in this direction. It must be admitted, however, that with the approach of all of these formations to the immediate vicinity of the cliffs of igneous rocks, beyond which none of them are known to extend, the lines of separation between shales and sandstones become less sharply defined.

The Basal Sandstone Series. Among all of the terms that have been used from time to time to designate certain formations and groups of formations in southeastern Minnesota, not a single one has been limited to the sandstone and shale series, lying between the St. Lawrence formation and the Keweenawan rocks, with sufficient constancy and definiteness to warrant general acceptance. A recent reference to these rocks

*Bull. G. S. A., vol. 6, 1895, p. 173. Magnesian Series, N. W. States.

by Norton* under the name *Basal sandstone* is the most acceptable yet offered. But the fact that this formation, instead of being uniform as the name would indicate, is made up of a succession of separable subdivisions, makes a slight modification of the term advisable. The term St. Croix series is a much better name, but as restricted by Winchell,† was not originally proposed for the whole group of rocks now under discussion and has not been uniformly applied by writers. Accordingly the term *Basal sandstone series* has been determined upon as a convenient name. It is intended as the coordinate of *Magnesian series* as used by Hall and Sardeson.‡ A prevailingly arenaceous character gives this basal formation a unity similar to that secured in the *Magnesian series* by its dolomitic development.

This series of sandstones, shales and conglomerates between the base of the overlying St. Lawrence formation and the Keweenawan floor, exhibits certain characters sufficiently constant to merit subdivision into at least three distinct parts.

The uppermost subdivision is a sandstone exhibiting two phases: (*a*) an incoherent fine sand, which is underlain, (*b*) by more compact and thick-bedded layers. Thin seams of green shale occasionally appear in this bed. Its thickness is about 100 feet at its most favorable exposure, Fossils are not well preserved within it, and they are not abundant except in one horizon. Because of the exceptionally fine exposures of this formation in the vicinity of the small village of Franconia, this uppermost division of the series is called the *Franconia sandstone.*

The second subdivision has a persistently shaly development in its uppermost and lowest members, between which is a green-sand bed, which is coarsely arenaceous. A typical section exhibits, in descending order:

Shaly sandstone, 10 feet.
Green-sand, 20 feet.
Gray shales, 40 feet, to the river, below which its extent is unknown.

The green-sand is a glauconitic mixture. Broken frag-

*Geol. of Iowa, vol. VI, 1897, p. 140.

†Geol. and Nat. Hist. Survey, Final Report, vol. II, 1888, p. xxi.

‡Bull. Geol. Soc. of America, vol. 6, 1895, pp. 167-198.

ments of Lingula shells are abundant. Cross-bedding characterizes this bed at Franconia. Fossils other than Lingula are not abundant within this formation. The conglomerates, however, that belong to this part of the Basal Sandstone series carry *Obolella polita* Hall, and *Lingulepis pinnæformis* Owen, besides other fragments not identified. Dresbach (a).

The third subdivision of the series is observable only above the Dalles, at Taylor's Falls, and at St. Croix Falls, in numerous exposures adjacent to the river channel. About 50 feet of this stratum is exposed, and the lower limit is always within reasonable estimate, since it occupies the comparatively shallow basin through which the river flows. This formation consists of sandy shales at several places; loose clayey shales extending farther up the river; calcareous shales in which thin layers of limestone one to three inches thick occur; and pyritiferous shales in which secondary iron sulphide in little pellets and grains make up almost one-third of the mass. Among these beds fossils are most abundant in the calcareous shales. The fauna is meagre in variety of species, but the number of individuals is unlimited. The species always obtainable is *Lingulepis pinnæformis* Owen. The pyritiferous shales also carry a few fossil species, the pyrite serving as the fossilizing agent, while other beds of the formation carry almost no fossil forms. Dresbach (b).

For these last two subdivisions as now limited the name Dresbach* of former writers is adopted. Dresbach, Minn., is the type locality where the succession was described by N. H. Winchell. Further proof of the correctness of the present correlation will be undertaken in the chapter on paleontology.

The Conglomerates. The diabase conglomerates of the Cambrian age, lying alongside some of the igneous cliffs and ridges, are both the most interesting of the local phases and at the same time the most responsive to investigation. Among the localities of most ready access are the following:

1st. At the water's edge, along the river, S. E. ¼, N. W. ¼, Sec. 15, T. 33 N., R. 19 W., where the conglomerate stands as a cliff 50 feet high with no visible ledge accompanying it at either side; 2d. On Mill street, in the village of Taylor's Falls, at the railway crossing, and at the brow

*Geol. and Nat. Hist. Survey of Minn., Final Rep., vol. II, 1888, p. xxii.

Bull. Geol. Soc. of America, vol. 6, 1895, p. 170.

of the hill as the street approaches the public school building. Other localities where contact of the Cambrian strata and the Keweenawan is marked by a conglomeratic tendency are:— At the river bank, St. Croix Falls, and at the test pit in N. W. ¼, S. W. ¼, N. E. ¼, Sec. 1, T. 33 N., R. 19 W., near the highway, three-eighths of a mile S. W. of the sandstone conglomerate outcrop.

At none of these places, however, is there any such extensive exposure as at the first two named.

The first mentioned locality is a prominent landmark on the river between Franconia and Osceola.* A narrow ridge runs out from the main river bluff squarely to the stream, where the vertical face, 40 feet in hight, reveals the cause of its successful resistance to the erosion which has worn back the sandstone bluff several rods. There is at this place an apparent absence of the rocks from which this conglomerate could have been derived. No outcrop of these rocks is to be seen on the same side of the river, although it is possible that the adjacent higher river bluff encloses or covers such a ledge. That this conglomerate has outlasted the parent cliff beside which it must have been formed seems to be a necessary conclusion. There is, however, an almost unbroken ridge of diabase extending from the railroad, two miles north of Dresser Junction to the river just opposite the conglomerate exposure and no doubt at one time was connected with it. River erosion has destroyed all connection which once existed between the two and which still may exist beneath the bed of the river. In such a way, indeed, an adjacent cliff may have been destroyed while favorable conditions saved a part of the conglomerate beside it.

The same fossil species occur in this conglomerate as are found in the adjacent shales. It belongs to the upper bed, the green shales, of the Dresbach formation.

Two outcrops of conglomerate on Mill street in Taylor's Falls, are probably continuous beneath the drift. Their marked differences in color, hardness, and compactness of the matrix are not of great taxonomic importance. The exposure at the brow of the hill is near the 875-foot contour line, and for convenience of reference will be called the upper conglomerate. The one at the railroad crossing is at about the 810-

*Owen: Geol. Survey of Wis., Iowa and Minn., 1852.
Section 4, from Marine Mills to the falls of St. Croix.
N. H. Winchell: Tenth annual report, Minnesota survey, 1881, p. 120.

foot line and will be referred to as the lower conglomerate. All differences noted between the two are satisfactorily explained by the fact that the upper conglomerate lies in immediate contact with the parent ledge, while the lower one represents the limit of the conglomeratic accumulation as it merges into the sandstones; the upper is thoroughly saturated with ferric oxide, while the lower contains more of the carbonates; the upper has been more effectually drained of the destructive alteration reagents which permeate the waters of such great reservoirs as sandstone strata become, while the lower has been more completely within their reach, so that its pebbles and boulders show both more extensive disintegration and a greater variety of secondary products. The cause of this difference between the upper and lower conglomerates at Taylor's Falls is still more strongly enforced by a comparison with that below Franconia, already described. In this latter exposure almost every boulder is well advanced toward the last stages of decay. Some of them are little more than an earthy compact mass—all now left of a once fresh lustre-mottled diabase, as is shown by the alternating blotches of green, gray and brown still to be seen upon the broken fragments. Still there is no evidence of any considerable time break between these conglomerates; and the differences of surrounding conditions due chiefly to their position, are believed to constitute the most potent cause of their variation.

All boulders of the conglomerates are of the same petrologic character as the eruptive rocks now, or at one time, in place in the vicinity. No specimen of any rock belonging outside of this group of diabases was found among them.

The conglomerate at Taylor's Falls belongs stratigraphically to the lower part of the Franconia sandstone member of the Basal Sandstone series, and extends downward into the next underlying member, the Dresbach sandstone. The diabase conglomerate at St. Croix Falls belongs to the lower shales member, and that before noted in Sec. 1, T. 33 N., R. 19 W., apparently belongs to the St. Lawrence formation.

Thus the conglomerates as a whole, do not belong to any single member or formation, but are accumulations, resulting from special surroundings, which may, and no doubt do, occur at all horizons from the first one laid upon the Keweenawan

floor to the uppermost member of the sandstone present in the St. Croix valley. Therefore each outcrop must be studied by itself and its position determined independently of the mere fact of its conglomeratic character or the proximity of other exposures.

The reason for the extended attention given to the conglomerates in proportion to their geographical extent, lies in the fact that within them is preserved the richest fauna thus far discovered in all the formations. The loose sandstones which constitute so great a part of the sedimentary strata are unfavorable for the preservation of fossil forms. The greater part of the shales is almost as barren as the sandstones, and such layers as do carry fossils, whether sparsely scattered or in multitudes, exhibit a narrow range of species. It is only in the conglomerates, as recent observations prove, that there existed comparatively favorable conditions for preservation. Among these rocks a remarkably abundant and new fauna has been discovered. Further description of these new forms will constitute a separate chapter of this paper.

Classification. A detailed study of the area at and adjacent to the Dalles of the St. Croix suggests the following formational subdivisions:

MAGNESIAN SERIES. (Hall and Sardeson.)	Shakopee dolomite.			
	New Richmond sandstone.			
	Oneota dolomite.			
	Jordan sandstone.			The St. Croix Formation. (Winchell.)
	St. Lawrence dolomites and shales.			
BASAL SANDSTONE SERIES. (Modified from Norton.)	3. Franconia sandstone (100 feet).			
	2. Dresbach shales (150 feet).	Obolella polita zone	Green-sands and shales	
		Lingulepis pinnæformis zone.	Calcareous & pyritiferous shales.	
	1. The lowest formation of this series is not exposed in the Dalles area, but it includes the lowest sandstone beds and possibly also the "Hinckley sandstone," (0 to 1,000 feet).			

CHAPTER IV. *Geology of the Igneous Rocks.*

A majority of the outcrops of igneous rocks lie within the erosion valley of the St. Croix river and thus owe their pres-

ent exposure to that stream. Notable exceptions to such distribution of the exposures are the prominent ridges, one to three miles distant from the river on either side, rising considerably above the surrounding drift. On the accompanying maps the location and surface extent of these rocks are given. The total area of their outcrops is about two square miles. In general, the occurrence and characters of the igneous rocks of this region have already been described by geologists.*

Many of these early descriptions are accurate and followed by logical conclusions. Present opinions of geologists are summarized in the following statements:

The igneous rocks of the St. Croix valley represent the southwestern extension of the volcanic flows and sedimentary strata known in the lake Superior region as the Keweenawan or Copper Bearing series. Irving insists upon the identity in essential characters of the igneous rocks of Keweenaw point and those of the St. Croix valley,† and this is considered by geologists the true correlation.

Keweenawan sedimentaries have not yet been observed in these southwesterly areas. The rock has been called most frequently a melaphyr. A serrate outline‡ of some of the outcrops and a step-like appearance of others has been referred to as indicative of the dip of these beds. A system of jointing planes is regarded as evidence of separate and perhaps numerous flows of molten matter. The vertical planes of this system represent an essentially basaltic fracture approximately perpendicular to the cooling surfaces; while the more persistent though somewhat irregular planes, more nearly horizontal, suggest lines of separation between successive flows. The dip of these planes, which is fairly uniform throughout the area, is, in the vicinity of St. Croix Falls, an average of 15 degrees W. by S.§

Differences in physical and mineralogical character corresponding roughly with the above mentioned separation planes, have been noted by the earlier geologists but not fully described. Conglomerates in contact with the volcanic rocks at numerous places are regarded as belonging to the next geologic age—the Cambrian.‖

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*Owen: Geol. Survey of Wisconsin, Iowa and Minnesota, 1852.
Chamberlin (Strong): Geology of Wisconsin, vol. III, 1880.
Upham: Geol. and Nat. Hist. Survey of Minn., Final Report, vol. II, 1888.
Winchell; 10th An. Rep. Geol. and Nat. Hist. Survey of Minn., p. 120.
Kloos and Streng: Neues Jahrbuch für Min., Geol. und Paleont., 1877. (Translation in the 11th Report of the Minnesota Survey.)
Kloos: Zeitschrift d. Deutsch. Geol. Gesells, 1871. (Trans. in 10th Minn. Rep.)
Irving: U. S. Geol. Survey, Monograph v, 1883.

†Monograph v, U. S. G. S., 1883, pp. 239, 240.

‡Geology of Wisconsin, vol. III, 1880, p. 369.

§Compare Geology of Wisconsin. vol. III, 1880, p. 420.

‖Geology of Wisconsin, vol. III, 1880, p. 417.

Additional Data and Discussion. Vertical or basaltic cracks and fissures are more numerous in some outcrops than in others. Outcrops west of the river and especially those in the immediate vicinity of Taylor's Falls, show this character in its highest development. Certain parts of the flows exhibit these joints to a more marked degree than others, the supposed upper portions of certain flows being singularly free from them. It is possible that the vicinity of the falls has suffered from additional disturbance, for jointing planes are especially abundant at the Dalles accompanied by large fissures. One of these large fissures has exerted a powerful influence upon the course of the St. Croix river at this place.

If one proceeds up the river toward the elbow without change of course so far as to the enclosing wall on the east side, it can be observed that there is an immense fissure in that wall extending without change of direction, but with converging sides back a considerable distance from the river. The vertical sharply cut walls of this fissure stand apart about 20 feet and widen in the direction of the river's course. At present the St. Croix turns almost a right angle at the elbow in the Dalles and flows westerly in a straight line between walls of solid rock for a distance of almost half a mile, while a continuance of its original southerly course in a channel through the same kind of rock for only 20 rods would have accomplished the same purpose. Such freakishness can be explained only on the ground of some structural aid in the misdirection of the river. The columnar structure of the rocks has made it possible to preserve almost vertical cliffs throughout the history of this river. The heat of summer and the frosts of winter levy contributions from year to year for the accumulating piles of debris at the foot of the cliffs. Some of these blocks drop into the river whose maximum depth, now 160 feet, is gradually but certainly diminishing. In view of the erosion effect above the falls it is scarcely possible to believe any such depth attainable in this extremely hard diabase rock without the acceptance of one of the following conditions: either the complete undermining of the igneous rock at its edge by the erosion of the underlying formation, or the occupancy of an original fissure line and plane of weakness by the river, making it necessary only to main-

tain a depth already secured. Of these two courses the latter seems the more reasonable. Any subsequent filling of this fissure by sandstone, shales or loose debris would present comparatively slight opposition to erosion.

The Lava Flows. Figure 3 is intended to represent a profile of the igneous rock surface including the river gorge immediately above the elbow at the Dalles. The profile is extended on the west side of the river to the Swedish church at the top of the ridge fifty rods south of the center of Sec. 25, and on the east to the top of the diabase cliffs. By this profile it will be seen that seven very prominent steps constitute the ascent on the west side of the river. At each step there is a repetition of certain easily recognized physical and structural characters.

These characters may be grouped as follows: At the summit of each step there is a persistent highly epidotic zone, possessing in many cases none of the original mineral characters of true diabase. Structures resembling flowage lines are observable only in this zone. In position and bearing these lines correspond closely to the previous statements of dip. A more persistent lateral plane of separation coincides with this zone, as will be noted by the wide bench leading in each case to the

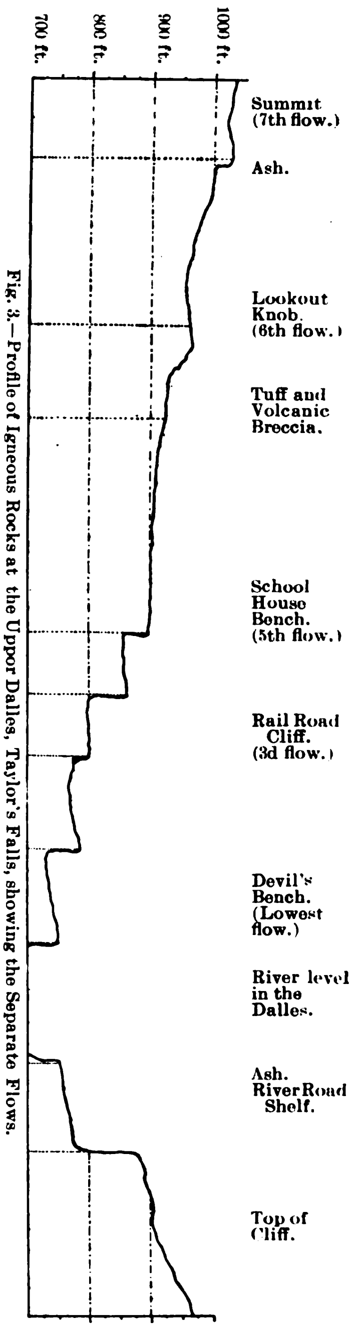

Fig. 3.—Profile of Igneous Rocks at the Uppor Dalles, Taylor's Falls, showing the Separate Flows.

foot of each step. In some instances also there is a zone of greater porousness at the top of each step than is usual in other parts, and greater local differences are developed in the rock. Greater hardness in places separated by areas more readily destroyed has given rise on one of these benches to one of the most magnificent exhibitions of pot-hole erosion anywhere to be found. In at least two places a decidedly schistose character has been developed at the immediate line of separation. In a good hand specimen the bands and veins show a considerable crumpling of the layer.

On the bench east of the river below the toll bridge the so-called flowage structure is extensively displayed. On certain portions of the bench above the public school building and at least at one point on the east side of the river a distinctly brecciated structure has been preserved. This is offered as an addition to the evidence of the complete independence of these successive steps and a proof of the theory of separate surface flows.

In this zone occurs a limited development of the tough blue diabase and the still more limited tufaceous rock which has been found at three different horizons at Taylor's Falls. (See chapter on the lithology of the igneous rocks.) In this zone secondary quartz is so abundantly formed in places as to make up almost one-half of the rock although secondary quartz is by no means confined to this plane.

Quartz veins, secondary feldspar, grains and threads of metallic copper occur. In no other corresponding portions of the flows are there any correspondingly great variations. At one point a quartz segregation, filling one of these lateral separation planes, has been worked for copper, but with no success.

The set of joints and columns is usually interrupted at these separation planes. Below this zone in every case the typical flow shows a considerable uniformity of adjacent areas, a stronger tendency to the formation of joints and columns, a very dark color and a typical diabasic texture. Lustre, mottling porphyritic development and chloritic alteration products are also more common.

The thickness of the several flows as thus separated varies between 30 and 60 feet. That they may include other thinner

beds similar in character and perhaps also following each other closely in point of time is quite possible. But that every lateral plain should represent a division between two successive flows is not in keeping with any single point of evidence. At other outcrops the thickness of the flows appears to be much less than at Taylor's Falls, but at no place is there a better opportunity for the study of so many flows in succession each of which is accessible throughout its entire thickness. Everywhere the topography is the feature first inviting investigation, but at no point so well as at the Dalles is the topography so perfect a guide to the exact divisional planes over so great an area.

Thickness. The total thickness of the Keweenawan at this point is not known. Accepting the dip of 15 degrees as fairly constant over the whole district, 4,000 feet will represent approximately the thickness of the rocks in sight. What the total thickness of the Keweenawan is at this locality is not known. The Stillwater well penetrated these flows from 717 feet to 3,408 feet of its depth.*

Folds in the Keweenawan Rocks. Adjacent areas from which data are obtainable bearing upon the Keweenawan surface, are the Kettle river outcrops at Chengwatana and vicinity, about 27 miles north, and at Stillwater, an equal distance south of the Dalles area. The Kettle river outcrops dip toward the east or south of east at a high angle. Seven or eight miles west of the St. Croix river this angle reaches 50 to 75 degrees, but passing eastward the dip flattens rapidly until it becomes very low, 10 to 15 degrees, at the outcrops along the St. Croix river itself.† These exposures are not over 900 feet above the sea.

At Taylor's Falls the outcrops show a dip of about 15 degrees toward the south of west at an elevation of 1,100 feet.

At Stillwater the Keweenawan igneous rocks were reached in a deep well at a depth of 717 feet,‡ which makes the surface of the igneous rocks coincide very nearly with mean sea

*A. D. Meeds, The Stillwater Deep Well, Bull. Minn. Acad. Nat. Sciences, vol III, no. 2, 1891, p. 274.

†R. D. Irving; The Copper-bearing Rocks of lake Superior, U. S. G. S., Monograph V, 1883, pp. 242-245.

‡*Loc. cit.*, Bull. Minn. Acad. Nat. Sci., vol. III, no. 2, 1891, p. 274.

level. Between Chengwatana and Taylor's Falls there is a trough which is the continuation of the lake Superior synclinal and which probably swings southward here.*

The strike of the exposures of diabase at St. Croix Falls, if projected beyond the area, passes 10 miles to the east of Stillwater. A dip of 15 degrees carries the strata down over 1,400 feet per mile, so that, if this angle were constant toward the southern limits of these rocks, they should not come within 13,000 feet of the surface at Stillwater. In fact they would pass to a lower level in the distance of a single mile from the last outcrop in the Dalles area than is actually reached at Stillwater. And the tendency of the strike to swing even farther eastward, as has already been noted, would serve only to increase the discrepancy.

Under these conditions it is clear that there is an extensive trough between Taylor's Falls and Stillwater which may be considered a secondary fold beyond the limits of the major synclinal fold of the lake Superior axis.

Unconformity. The unconformity between the Keweenawan eruptives and the Cambrian sedimentaries is nowhere more clearly marked than at Taylor's Falls and St. Croix Falls. Wherever the actual contact of these two formations is seen, evidence is clear of the immense time and erosion interval between them. Four or five such contacts are known in the exposures within the immediate vicinity of the Dalles on both sides of the river.

Differences of erosion of adjacent areas, amounting to 400 feet, accomplished previous to the deposition of the earliest shales, is shown along the present course of the St. Croix river. This is probably no exceptional occurrence, but is a fair example of the general erosion previous to complete submergence.

DRUMLINS CONTAINING OR LYING ON MODIFIED DRIFT.

By WARREN UPHAM, St. Paul, Minn.

The occurrence of beds of sand and gravel inclosed within oval accumulations of till, which in all other respects appear to be typical drumlins, has been reported in several of my

*R. D. Irving: The Copper-bearing Rocks of Lake Superior, U. S. G. S., Monograph v, 1883, p. — and map.

former papers.* In the localities thus studied and described, the nucleal beds were evidently of contemporaneous origin with the till. While the drumlin hill was being amassed, for a considerable time the drift forming it was stratified gravel and sand, brought and deposited by streams of water from the melting of the overlying and wasting ice-sheet. Other parts, basal and superficial, were till, being unstratified glacial drift deposited directly from the ice, without modification by water action.

Drumlins are attributed, in these papers, to convergent currents of the border of the ice-sheet when a layer of drift, having become superglacial, as on the Malaspina glacier, was enveloped by a later onflow of ice above it, being then amassed englacially or subglacially in these hills very near to the boundary of the ice, that is, within a few miles or probably in some cases within even less than one mile. Subsequently this opinion has received some confirmation or support from Greenland, where, beneath the terminal cliffs of its inland ice and peripheral glaciers, masses of drift were seen and photographed by Chamberlin, with the ice lamination curving drumloidally over them.†

Although the drumlins, like the Wisconsin and later moraines, belong to the general time of Late Glacial or Champlain retreat and final departure of the ice-sheet, this view of their origin ascribes their formation to substages when the recession of the ice boundary was much slackened or even was interrupted by a temporary readvance. The edge of the ice-fields was then thickened by exceptionally abundant snowfall during a series of years, and by outflow of the higher ice from some distance back of the border. According to my studies and mapping of drumlins and associated drift deposits in New Hampshire and northern and eastern Massachusetts, it seems to me probable that in this region mainly the glacial recession

*Boston Society of Natural History, vol. XXIV, pp. 228-242, April, 1889; vol. XXVI, pp. 2-17, Nov., 1892, with discussion by Profs. W. M. Davis and G. H. Barton (pp. 17-25).

AM. GEOLOGIST, vol. X, pp. 239-262, Dec. 1892, including bibliographic notes; vol. XIV, pp. 69-83, with sections of drumlins in Scituate, Mass., containing nucleal stratified deposits, and a map of drumlins in Madison, Wis., which consist mainly of a nucleus of modified drift.

†Bulletin, Geol. Soc. Amer., vol. VI, pp. 199-220, with eight plates, Feb., 1895.

was only slackened while these hills were being accumulated. But glacial readvance probably attended the formation of drumlins in central New York, where Davis has observed sections of these till accumulations lying on beds of gravel and sand which were somewhat eroded before the deposition of the till.

Wherever free drainage from the ice border permitted the waters of the glacial melting and rains to flow away, bearing the fine rock flour and clay in suspension, the nucleal and basal modified drift accompanying the drumlin till consist of gravel and sand, which could be deposited from running streams. In New Hampshire, during my observations of many sections of drumlins and of allied lenticular slopes of till resting on rock hills, a few instances were noted having such coarse modified drift, from a few inches to five feet or more in thickness, lying between lower and upper deposits of till which were interpreted as respectively subglacial and englacial drift when the ice-sheet was finally melted away.*

On the other hand, where drainage could not take place freely during the departure of the ice-sheet, the water being ponded against the ice border, as in the extensive basins of lakes Winnipesaukee and Squam in central New Hampshire, very remarkable beds of horizontally stratified clay, sometimes free from stones and gravel, but occasionally containing many small rock fragments dropped from the overlying ice, were formed between a lower subglacial till and an upper englacial and finally superglacial till. The upper till varies in thickness up to 10 feet; and the stratified clay next below is usually only a few feet thick, but in some places, well exposed by excavations for brick-making, it is 20 to 30 feet thick. It occurs, here and there, at all altitudes up to 300 feet above these lakes on the adjoining drift-covered high rock hills; but no deposits of stratified clay are found in this district without the thin envelope of the upper till.†

Comparing these observations with the sections of stratified brick clays noted by Marbut and Woodworth in Somerville, Medford and Saugus, Mass., we may well ask, in the few places where those stratified clays are seen to be overlain by

*Geology of N. H., vol. III, 1878, pp. 289-291.

†Geology of N. H., vol. III, pp. 131-137.

till, whether both the clay beds and till may be referable to nearly contemporaneous deposition from the waning ice-sheet, like the modified drift found elsewhere in and beneath drumlins, and like the clay beds on the hills surrounding lake Winnipesaukee. This interpretation of the relations of the brick clays and overlying till, the latter in part amassed as drumlins, seems to me better in accord with other features of the glacial geology of eastern Massachusetts than the view presented in their paper (with the joint authorship of Prof. Shaler), namely, that the stratified clays were overridden by a readvance of the ice-sheet from the vicinity of Boston to its former limits on Martha's Vineyard and Nantucket.*

This stratified clay formation, extensively used for brickmaking beside the Mystic river estuary, is chiefly free from any covering of till and boulders, which would be expected to extend continuously over it as a mantle if the ice-sheet readvanced across this area after the clay beds were deposited. Therefore, instead of the interglacial origin suggested by these authors, the brick clay seems to me to be a part, like the clay beds in the Connecticut and Merrimack river valleys, of the large amount of modified drift which was deposited progressively while the ice-sheet was retreating, earliest southward and later northward, during the Champlain or closing epoch of the Glacial period. The upper limit of these clays, generally 10 to 20 feet above the present mean tide sea level, is probably the measure of the maximum Champlain depression of this part of our coast. Being deposited in the somewhat enlarged Mystic estuary close to the receding ice border and perhaps in part under the edge of the ice, as in the vicinity of lake Winnipesaukee, the stratified clays may in some localities of small extent have become covered by the contemporaneous till formed likewise under the edge of the ice-fields, whether spread somewhat evenly or heaped in drumlins. Hence it seems more likely that the brick clays reach only slightly under the edge of the drumlins and other ascending slopes of till than that they continue under the entire drumlin masses, as shown by Marbut in his diagrammatic sections.

*U. S. Geol. Survey, Seventeenth Annual Report, for 1895-96, pp. 951-1004, with maps and sections (noticed in the AM. GEOLOGIST of last month, p. 328).

Elsewhere the evidences of readvances of the ice-sheet in our Atlantic coastal region, afforded by fossiliferous beds underlain and overlain by glacial deposits, as observed by the present writer in southeastern New Hampshire,* by Prof. C. H. Hitchcock at Portland, Maine,† and by Mr. Robert Chalmers near St. John, N. B.,‡ appear to indicate only moderate fluctuations of the border of the continental ice-sheet. Nowhere east of the Ohio is a great glacial readvance demonstrated by plentiful fossiliferous interglacial deposits and an old land surface, like those of the forest bed next underlying the Iowan till in the upper part of the Mississippi basin.

A SPHINCTOZOAN CALCISPONGE FROM THE UPPER CARBONIFEROUS OF EASTERN NEBRASKA.

By JOHN M. CLARKE, Albany, N. Y.

(Plate XXIII.)

In the prosecution of investigations upon the Carboniferous and Permian formations of Nebraska and Kansas,§ professor Charles S. Prosser, of Union College, Schenectady, N. Y., collected a series of interesting specimens of a calcisponge which he has kindly given me the opportunity of studying. As these prove to represent a group of sponges not before observed in American fossil faunas, they are entitled to brief notice. The geologic position of these bodies is the Wabaunsee formation (Prosser), the middle division of the upper Carboniferous, at the villages of Nehawka and Weeping Water, Nebraska, where they are associated with well known species, such as: *Seminula subtilita*, *Derbya crassa*, *Enteletes hemiplicata*, *Chonetes granulifera*, *Productus longispinus*, *Hustedia mormoni*, *Spirifer cameratus*, *S. lineatus*, etc., etc.

These specimens represent a species of the annulated and chambered calcisponges which have been found at various places in the upper Carboniferous and Mesozoic formations of Europe and Asia. Many of them bear a striking resemblance,

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*Geology of N. H., vol. III, 1878, p. 163.

†Proc. A. A. A. S., vol. XXII, for 1873, pp. 163-175. Geology of N. H., vol. III, pp. 279-282. Geol. Magazine, II, vol. VI, 1879, pp. 248-250.

‡Bulletin, G. S. A., vol. IV. 1892, pp. 361-370.

§See Journal of Geology, vol V, no. 1 and 2, 1897.

both without and within, to the cylindrical, chambered, siphonated shells of *Orthoceras*, and, indeed, the first of them to be described was termed *Orthoceras vesiculosum* by DeKoninck.*

These sponges have been grouped together by Steinmann under the name *Sphinctozoa*.† This author has divided all the extinct members of the order *Calcarea* or *Calcispongia* into the two groups, *Inozoa* and *Sphinctozoa*, and the latter are thus defined:‡ "*Sphinctozoa*. The simple or compound sponge-bodies consist of ring-, or ball-shaped segments. Their outer wall is penetrated by simple, and for the most part, straight canals, or is quite solid."

In contradistinction to these the *Inozoa* are defined as thick, massive and compound, and penetrated by branching canals.

Among later writers, Rauff,§ and, following him, Zittel,‖ regard the most of these *Sphinctozoa* as related to the existing calcisponge *Sycon*, on account of the simple character of the radial canals and have hence assigned them to Hæckel's order *Sycones*. It has been clear to all students of these fossils and is very evident in the specimens now under consideration, that skeletal spicules are of great rarity or seldom distinguishable, the walls being a compact, calcareous mass with coarse perforations and often a distinctly fibrous structure. Steinmann laid little importance upon the existence of a coarse, vesicular structure in these *Sphinctozoa*, possibly because it was not clearly exhibited by his specimens, but in those described by Waagen and Wentzel, from the middle Productus-limestone of India,¶ as well as the Nebraska specimens, this vesicular structure is very pronounced, the vesicles being produced by laminar diaphragms arching from one wall

*Quart. Jour. Geol. Soc., London, XIX, p. 15.

†G. Steinmann; Pharetronen-studien (Neues Jahrb. für Mineral., 1882, 2, pp. 139-191, pls. 6-9). Both here and elsewhere Steinmann has regarded these bodies as Pharetrones (see also Steinmann and Doederlein, Elemente der Palæontologie, pp. 70-73, 1890), employing this term in, perhaps, a somewhat broader sense than did Zittel in erecting it into ordinal value.

‡Palæontologie, *ut cit.*, p. 71.

§Palæospongiologie, 1st Th., pp. 100-102, 1893.

‖Grundzüge der Palæontologie, p. 61, 1895; and Eastman's Zittel's Text-book of Palæontology p. 65, 1896.

¶See Memoirs, Geol. Surv. India: Palæontologia Indica, Ser. XII Range Fossils, 1, Productus-limestone, 7, pp. 967, *et seq.*, pls [illegible] 1887.

to another of the interseptal chambers or intersecting other diaphragms. The presence of this structure, when well developed, has suggested to Waagen and Wentzel the possibility of a relationship to the corals and that the Pharetrones are actually more highly organized than the true sponges, and form a transitional phase between the *Spongiozoa* and the corals.

We may observe that of the sphinctozoans discussed by Steinmann, the majority of the genera are from Mesozoic faunas. All the paleozoic genera known are from the upper Carboniferous rocks of the Asturias, the Salt-Range, and now from Nebraska, and bear the names, *Sollasia*, Steinm., *Amblysiphonella*, Steinm., and *Sebargasia*, Steinm.

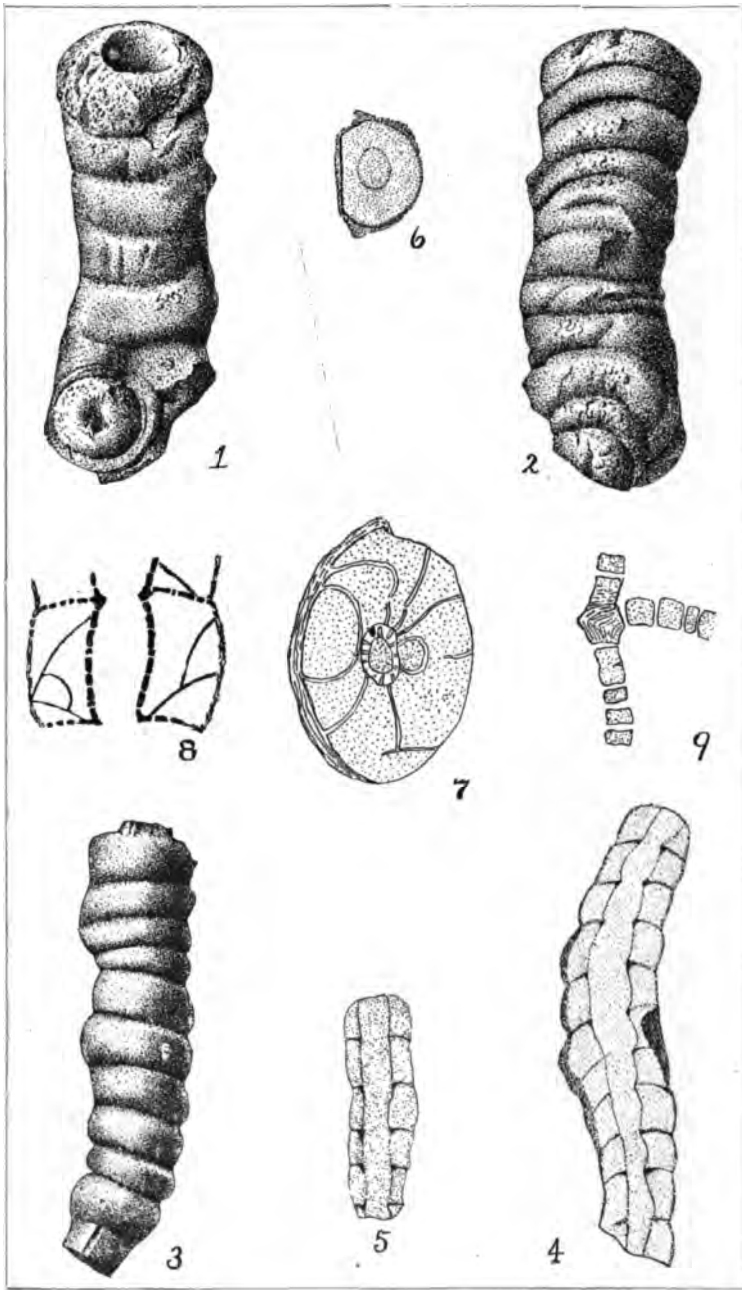
The bodies from Nehawka and Weeping Water are simple subcylindrical individuals, straight or gently curved, the largest fragment measuring 70^{mm}, and indicating an entire length not exceeding 100^{mm}. The fossils are from a calcareous shale and have, for the most part, been somewhat compressed. Their interior cavities, the cloaca and the interseptal chambers, are filled with compact grey limestone distinctly and finely oolitic, and their exteriors are frequently entangled with encrusting bryozoa and remains of other fossils. The septate or annulate aspect of the exterior is always shown, and when this external surface is free of other organic remains and cleansed of the attached matrix, it presents the aspect of a *Fistulipora* or of a small celled *Alveolites*; that is, the mesh-work of the skeleton is made up of polygonal cells, all of small size, not always opening directly outward, but in places frequently presenting oblique apertures. So fine is this superficial network, and so uniform the size of the cells that one might casually interpret the entire fossil as a macerated *Orthoceras* overgrown with an encrusting bryozoan.

One of the specimens is preserved with its aperture entire, which shows it to have been a simple, narrow circular cavity. On cutting these bodies along their longer axis we observe, first, a continuous central cloaca, relatively much wider than would be the siphon of an orthoceran of the same size, but slightly constricted at intervals, where its walls meet the septa. This cloaca is delimited by a well-defined circular wall, and thus has no communication with the septal chambers or the cavities of the annuli, except through the perforations in

this wall. The septa are at quite regular intervals and are convex upward. On the gastral surface they project slightly inward, as observed, into the cloaca.

Each of these septa represents a former apertural surface, and the sponge affords, thus, an interesting instance of periodical intensity of the growth-force. The walls of the sponge thus exposed in section are very thin, approximately uniform in this respect, and all are perforated with straight, simple and relatively large canals. Those traversing the gastral wall (exhalent pores) are larger than the rest and appear to be of uniform size. The canals perforating the septal (that is, apertural) and exterior walls, are the inhalent pores, and with this necessary interpretation the septal cavities may properly be regarded either as chambers for the accumulation and discharge into the cloaca, or as true ciliary chambers. We find that, for the most part, these skeletal walls have been, perhaps by secondary changes, converted into crystalline calcite, and this change has obliterated the spicular structure, and in some places the perforate structure of the walls. Elsewhere, especially on the external walls, there has often been a deposit of adventitious calcite which, in sections, gives the wall an unusual thickness.

It is to be noted that there is no breach in the continuity of the external wall of any given annulation. The septal or enclosed portions of the wall do not meet the outer or exposed part as they meet the gastral wall, but the entire external wall is arched from the peripheral base of the chamber beneath, to the apertural margin of the cloaca. Reference has been made to the vesicular tissue formed in the intermural chambers by thin arched tabulæ which may pass from the gastral to the dermal wall or, if numerous, extend from one to another. These laminæ appear to be composed of compact fibrous tissue which shows a tendency to part along a median plane as though constituted of two distinct layers. Steinmann did not emphasize the presence of this structure in any of the material embraced by him within the family *Sphærosiphonidæ*, but observed it as highly developed in his genus *Cryptocoelia*. Waagen and Wentzel's view, above expressed, that the production of such vesicular tissue is an altogether too progessed function for a true sponge, is a suggestion too well



AMBLYSIPHONELLA PROSSERI *Clarke.*

grounded to be disparaged, but their further inference that the existence of such tissue signifies relationship to the corals must be reconsidered in the light of the fact that vesiculation of exoskeletal tissue is the undoubted accompaniment of permanent or temporary fixation, as evinced by the brachiopods, gastropods, lamellibranchs, bryozoans and the corals themselves.

In comparing the structure of these fossils with the various generic divisions of the sphinctozoans erected by Steinmann, it is seen that they belong to this author's family, *Sphærosiphonidæ*, which embraces the genera *Barroisia*, Munier-Chalmas (Aptian), *Enoplocœlia*, Steinm. (St. Cassian), *Thalamopora*, Roemer, *Amblysiphonella*, Steinm., (upper Carboniferous, Sebargas) and *Sebargasia*, Steinm., (upper Carboniferous, Sebargas). All of these forms possess a more or less complete central cylinder, and in the genera *Barroisia*, *Amblysiphonella* and *Sebargasia*, the generic difference is very obscure; in the last two the sponge has a much more strongly annulated exterior than in the first, and between *Barroisia* and *Sebargasia*, and *Amblysiphonella*, there is a palpable difference in the size of the meshes or pores of the skeleton, these being larger in the two former. On further investigation, it may prove difficult to maintain more than a specific difference in the forms referred to *Sebargasia* and *Amblysiphonella*, and to the former we should be disposed to ascribe the Nebraska species, on account of closer agreement in the size of its pores, with the single described form of *Sebargasia*.

Waagen and Wentzel have, however, referred the Salt-Range species which are, structurally, like ours, to the genus *Amblysiphonella* from which they depart, in the presence of vesicular tissue, quite as widely as from *Sebargasia*. In deference to this employment of the term, we therefore designate the Nebraska species as *Amblysiphonella prosseri*.

EXPLANATION OF PLATE.

AMBLYSIPHONELLA PROSSERI Clarke.

Upper Carboniferous (Webaunsee formation), Nehawka and Weeping Water, Nebraska.

FIGURES 1 and 2. Opposite sides of a nearly entire specimen, showing the aperture.

FIGURE 3. A more slender and more strongly annulated specimen.

FIGURE 4. Longitudinal median section, showing the central tube or cloaca, and the septa, with the perforations in both.

FIGURE 5. Fragment of a smaller specimen with a less constricted cloaca.

FIGURE 6. Cross-section, showing the perforated outer and inner walls.

All the above figures are natural size.

FIGURE 7. Cross-section enlarged, showing the oblique laminæ crossing the interseptal spaces and forming a coarse vesicular tissue.

FIGURE 8. Enlargement of a portion of the cloacal wall and septum.

FIGURE 9. Median cross-section of an interseptal cavity, showing the curving laminæ: enlarged.

ON GLACIAL DEPOSITS IN THE DRIFTLESS AREA.

By F. W. SARDESON, University of Minnesota.

The "driftless area" of Wisconsin, Iowa and Minnesota has been believed, as the name implies, to be entirely devoid of glacial deposits. It is doubtless devoid of "northern drift," and this fact is worth expressing in the name of the area whether or not it has local drift deposits upon it. The name need not imply that there never existed Pleistocene glaciers within the area's borders, although such is indeed asserted to be the case by American glacialists. I shall use the name here with the reservation that "driftless" means without northern drift. I may explain briefly, that a former teacher, Prof. G. Steinmann, had told me, that from knowledge of other continents he should deduce the theory that the driftless area of Wisconsin has been occupied more or less by local glaciers: and while working a few days in this region last August, I have indeed found some deposits which I cannot explain as anything but local glacial moraines, and which would certainly not be called anything else if found in drifted regions.

My opportunity for study of this "driftless area" has been limited and I shall not therefore attempt to maintain any theory of its glaciation, nor to present a description of its Pleistocene deposits, except to describe some of them in connection with certain non-glacial deposits of the drifted regions which appear also to be important factors in the study of the Pleistocene. It was mainly for the purpose of explaining the latter that my visit to the "driftless area" was undertaken. These same non-glacial deposits associated with the northern

glacial drift, have been apparently often passed by lightly as drift deposits or modified drift, and also, as it would appear, the glacial phenomena of the "driftless area" have scarcely been considered, and a study of certain phenomena of the drifted and driftless areas together will, it is hoped, reveal them both more clearly.

The Loess and Dune Sands. In this "driftless area" the uppermost deposit is the loess formation, consisting chiefly of loess loam. The deposit has been described from several counties of Minnesota, Iowa and Wisconsin, and is well known to be continuous with loess that covers the more ancient glacial drift surrounding the area. It is not a local deposit. It covers nearly the entire "driftless area," although much of its extent has been described as residuary clay of the disintegrated Paleozoic rocks.* It differs from this residuary clay structurally, and is separated from it. Outside the "driftless area," drift intervenes between them. For example, at Freeport, Illinois, at the west side of the city in quarries, one sees:—

Loess loam.............................	6 feet
Loess..................................	0 to 6 feet
Northern drift.........................	thin
Residuary clay.........................	1 to 2 feet
Galena limestone.......................	20+ feet

Farther north the unchanged loess and the "northern drift" become more and more frequently absent until in the "driftless area" the residuary clay of the loess, loess loam, rests upon that of the limestones, as a rule, but the same are always distinct. No one has doubted that the residuary clay of the loess above the drift is continuous with that described here as loess loam of the "driftless area," although there has been confusion as to the origin of the latter. In places where the loess loam without loess occurs it is understood that the loess has been entirely reduced to loam, and only where a greater depth of loess existed does any of it remain. I observed this formation particularly in the Peccatonica river basin in southwestern Wisconsin, where it is associated with some wind-driven sands that aid in explaining its origin.

This sand deposit is abundant in the valley, irregularly

*J. D. Whitney, Geol. Wisconsin, vol. 1 (1861); Chamberlin and Salisbury, 6th Ann. Rep. U. S. Geol. Survey, p. 239, (1885).

distributed above the flood plain of the river and upon the slopes. It is a loose sand made up of rounded quartz grains and some impurities, and shows no bedding, except where runs have washed across it during its accumulation. The sand has been derived from the Saint Peter sandstone evidently, in this valley. The river has cut a wide valley through the Maquoketa shales and Galena limestones, through the Saint Peter into the Shakopee formation and in many places into prominences of the Oneota dolomite, so that the Saint Peter sandstone borders the valley on both sides for 30 miles. We have no reason to doubt that the loose sand has been derived chiefly from the Saint Peter, especially since no other probable or possible source is known. I do not know that anyone has ever distinguished this sand from the Saint Peter, heretofore. When it rests upon that formation it is distinguished by its entirely loose structure and by impurities. and by polished concretions of iron, and polished blocks of Saint Peter sandstone or by chert fragments that lie upon the once denuded surface of sandstone upon which the sand now rests. That the loose sand is not mere residuum of the Saint Peter is proved by the fact that it often extends upwards over the Beloit and Galena formations which overlie the Saint Peter. This is seen well near Argyle, LaFayette county. Again loess loam instead of the sand often covers areas of St. Peter sandstone.

It is a wind driven sand deposit contemporaneous with the loess from which the loess loam resulted, and into which the sand graduates in many places on the slopes of hills. I can not otherwise explain it, than as wind driven sand because the sand grains have been driven up hill in many cases, and up the valley, or north instead of down it; because the sand shows general lack of sorting; and because it includes here and there assorted sand where small temporary streams have crossed it during its accumulation, showing that it was a land area. The gradation from sand into loess ascending the slopes, without any stratification reminds one not at all of water action. Where the valley is open to southwestern winds, there especially the upward transportation of this sand has obtained.

The thickness of the sand is from 0 to 20 feet. The loess

loam is, on the contrary, quite uniform, being about four feet or less. The sand forms local patches, while the loess loam is continuous with that of distant regions. Consequently the source of the sand may well be believed to be cf local origin as explained, the loess, on the contrary, partly local but mainly of foreign origin. The loess could not have been derived from the residuary clay of the limestones of the area since that clay is still uniformly covered under the loess; nor from a part of that clay unless the same had been uniformly moved off and back again, which is difficult to imagine, for so great a mass. If one consider the loess loam as a residuary clay from the Paleozoic rocks he has these objections to answer: How could two kinds of residuary clay form, one above the other, the lower one with residuary quartz or chert, the upper without them; the lower as a rule on limestone and clay only, the upper one on sandstone also; the lower one extending under the true loess when it is present, the upper one extending over the same? The origin of the loess loam was most probably from loess, the loess from remote regions chiefly.

There is found in Minnesota and Iowa evidences of wind action on large scale. Especially in Isanti, Anoka and Chisago counties of Minnesota, are sands in structure like the wind driven sands of the Peccatonica valley. Warren Upham has described and interpreted some of them:

Dunes of sand, gathered from the modified drift by the wind, and heaped up in mounds and ridges 10 to 20 feet high, occur in the south part of sections 34, 35 and 36, Grow, Anoka county. They are blown into frequently shifting forms, like drifts of snow, and are too unstable to give a foothold to vegetation. It seems most probable that they were gathered from the coarser sand and gravel of the surrounding area soon after the deposition of these beds, before they became covered, and protected from wind erosion, by grass, bushes and trees."*

Colonel Folwell, first president of the University of Minnesota has described to me the same kind of an area which formerly existed on and near the present site of the University campus. This area was gradually reclaimed mainly through the sand-bur, (*Cenchrus tribuloides* Linné) he informs me. Evidence of this area still exists in a deposit of loose sand, (see fig. 17, p. 297, op. cit.) covering a long distance. Areas

*Final Rep. Minn. Geol. Nat. Hist. Survey, vol. II, p. 418.

of loose sand covered mainly by vegetation, often by large trees and formerly no doubt by primeval forest, have been seen by me in Hennepin, Ramsey, Washington, Anoka, Isanti and Chisago counties in Minnesota, and although my exploration has been merely incidental and not extensive, still there seems to be evidence enough to warrant the belief that deposits of wind-driven sand in this region are really very extensive. In all cases except one these sands have been interpreted as water deposits*—modified drift—the evidence for which these sands do not bear. There is true modified drift too in the region. The ancient wind-driven sands are also extensive and very evidently the little desert in Anoka county, described by Warren Upham, represents only the *remnant* of a much larger one.

The source of the sand here is the drift, since the whole region is drift-covered. Of course already sandy areas have afforded conditions for the greatest accumulation and hence the sand is often associated with the modified drift. It is spread or heaped over terraces and over hills, especially deep on top of low hills, as near Harris.

Associated in the neighboring area is also a loess loam, seemingly of the same age, for example in Washington and Dakota counties, Minnesota. Winchell (N. H.) writes of the former county: "on the most elevated tracts, is found a light clay-loam, of a yellowish color, which is comparable to that found in similar situations in Dakota and Goodhue counties." (Vide op. cit. p. 380, l. 33). The loam of Goodhue county is the pre-Wisconsin loess, the other post-Wisconsin. Salisbury has recently interpreted some deposits of loess upon the Wisconsin, although the deposits described by him are not adjacent to the Anoka desert. "Heretofore loess has not been known to occur in or above the drift of the Wisconsin epoch; but during the past summer it has been found in connection with this formation at several points in Wisconsin, namely near Green lake, Devil's lake and Ableman's."†

Besides the sand and loess deposits that are known to lie upon the Wisconsin drift there are probably other perhaps larger contemporaneous ones. Yet the post-Wisconsin as

*Vide loc. cit. p. 254, fig. 16, p. 295, 297, 352, 371, 380, 404, 411.
†Salisbury, 1896, Jour. Geol. IV, p. 930.

compared to the pre-Wisconsin loess is no doubt inconsiderable in amount. The relatively modern and inconsiderable deposits of loess and loess sand, nevertheless, are of very great interest since they may be a true indication of what the great loess periods were. The Wisconsin glaciers obliterated part of the great loess deposits; did it first overrun large associated deposits of wind-driven sands to the northward?

It may be that the Wisconsin drift lies here and there upon old lake beds and swamps, and that just preceding the glaciation the climate was not that of a desert. There may have been such a period of erosion and non-deposition of the loess formation. But if we consider the period of loess accumulation itself, who can say that a desert did not exist then on a large scale? In Fillmore county, southeastern Minnesota, I have noticed beds of finely polished pebbles on the top of the Iowan drift. They are on high land, 1200 feet elevation; they are not waterworn pebbles, they are not rough-etched like the chert in residuary clay, but are very smooth like the wind-sand polished surfaces found on exposed quartzite rock of southwestern Minnesota. It is not now possible for me to tell whether abundance of such materials existed, but possibly they did and evidence of it may be looked for.

Turning again to the explanation of the desert sand of Anoka county, as sand gathered by the wind from the modified drift at a time following the retreat of the glacier, and adding that as sand was driven so fine dust was at the same time transported to higher and more remote hills, we have one of the accepted theories regarding the loess deposits exemplified. If following the Iowan drift period, an arid region prevailed through which retreating glaciers poured flooded rivers there was an ideal condition for the driving of dust onto the hills and the formation of loess. The Wisconsin glaciers could have again obliterated the sand plains and its rivers worked over the valley deposits so that little except the loess could remain.

Chamberlin and Salisbury (op. cit, p. 286) have discussed the origin of the loess around the "driftless area," and have presented as an objection to the æolian hypothesis the very phenomenon which I would else have presented as evidence of it, viz., "the predominant distribution of loess along the great

valleys," (p. 287). And in this connection I may cite their description of dunes, which may perchance prove of the same nature and age as those of the Peccatonica valley.

"The eastern bluffs along the Mississippi are frequently crowned by dunes of fine sand blown up from the valley below. These are usually composed of finer sand than is common to dunes in general, and this graduates almost imperceptibly into silt scarcely coarser than that of the loess itself; indeed not coarser than much loess on the face of the bluffs of the Mississippi, whence, indeed the dunes seem to be partially derived. From these dunes there spreads backward to the east, i. e. to the leeward, a mantle of fine sand graduating indefinitely away into a deposit indistinguishable from loess proper." (Op. cit. p. 286.)

The " northern drift" is a more probable original source for most of the loess loam of the "driftless area" than is the local residuary clays although both may have contributed.

The Residuary Clay and the Glacial Phenomena. It is not possible as it seems to me, that the loess loam covered portion of the "driftless area" of Wisconsin, Minnesota and Iowa could have been glaciated since the deposition of the loess upon it. Regarding the highest points, like the Blue mounds and Platt mounds, I cannot now tell, but glaciers could not have been very extensive during the Wisconsin period, since the Iowan loess mantle is very extensive. Evidence of previous glaciation must be sought under the three to six feet of loess loam.

Residuary clay of the Paleozoic rocks, the same of which Chamberlain and Salisbury say, "the deeper-lying clay where limestone is the adjacent rock, is the most characteristic member of the residuary earth series" (op. cit. p. 239), is as a rule wanting upon sandstones even where limestone had formerly rested, although it is represented often by a few chert fragments, concretions or polished blocks of sandstone. This residuary clay is a structureless, dark red-brown, stiff clay with irregularly intermixed fragments of chert from the disintegrated limestones. It is found upon limestone, dolomite and clay surfaces, and reaches down into crevices or again rests upon frost-broken rock. It clings tenaciously on the hillsides and I have been surprised at times to find it thickest where I expected to find it eroded thin.

At Freeport Illinois, 20 miles within the limits of northern drift, the same residuary clay is in place in full thickness,

thus showing that glaciers did not necessarily remove it. I have found residuary clay on the Niagara limestone in places in Iowa where glaciation had twice obtained. At Freeport the northern drift is mixed in the upper part of the residuary clay, but otherwise the latter is not peculiar. It seems to me evident that the existence of residuary clay in the "driftless area" is not proof that no glaciers existed there, during the Iowan and Kansan (or pre-Kansan) drift periods. If at Freeport the glacier had carried only residuary clay and chert, without northern drift, we should probably scarcely find traces of its former existence. Local glaciers in the "driftless area" would evidently descend along the natural valleys merely, transporting materials in the direction of the surface drainage, and probably but little materials at that. Under a loess mantle slight evidence of drift is easily concealed moreover. Along the railway from Freeport to Dodgeville is one favorable line for investigation, because of the cuttings, and there I have been able to devote a few days only to this and other geological investigations.

About four miles below Dodgeville, Wisconsin, the Illinois Central railway cuts through a mass of unstratified residuary clay with chert besides some loose blocks of Saint Peter sandstone. The clay here, as not rarely elsewhere, contains rounded grains of quartz, probably from the sandstone. The exposure is ten or more feet deep and about 100 long, and no evidence of water action was found in any part of it, but only the characters of boulder clay. The mass appears superficially to be 20-30 feet thick, 300 yards long across the valley and 200 yards wide. The creek or river has cut across its west end, else the mass obstructs the valley. Its position revealed to me no explanation of any origin except that of an end moraine. It lies in the horizon of the Saint Peter sandstone, above the flood plain of the river and had it not been for fortuitous exposures it might have been passed over as one of the loess-covered Shakopee and Oneota dolomite swells that are so common in the East Pecatonica valley.

Half a mile farther down the valley, the railway cuts through a loess-covered Oneota dolomite swell high above the flood plain of the river. The dolomite formation is covered by residuary clay, and on the lower or southern side by an

extensive mass of red clay, chert and sandstone blocks mixed together. A half mile farther another cut enters first through Saint Peter sandstone, then 100 yards through clay with chert fragments and sandstone blocks. This mass rests upon an irregular sandstone surface and is about six feet thick, covered by a six-foot mantle of undisturbed loess loam. The base of the exposure is fifteen feet above the flood plain of the river. At the southern end of the cut the chert and clay drift dips below the grade and probably extends a considerable distance down the valley.

The three described masses of clay and chert are explicable only as the successive moraines of a glacier, that descended the valley from its head, five to six miles distant. How much farther the glacier may have previously extended I can not tell, but possibly to the limits of the "driftless area." I examined many exposures of residuary clay farther down the valley but came upon no accumulations like those described. One is everywhere reminded that no accumulation of clay and chert would have remained intact. The residuary clay upon the appertaining formations is uniformly thin and alike thin whether the latter are little or much reduced in thickness. Seemingly conditions had been such that the clay was swept off gradually following closely its growth from beneath, and in such a manner that it did not creep down the slopes onto the sandstone, nor remain accumulated. Moraines of loose clay would probably have been obliterated, leaving only their contained quartz fragments, which same are not safely interpreted as moraines because such heaps may be due to unequal distribution of the chert in the decomposed strata. Thus, too, the polished surfaces of the same fragments are not safely attributed to glaciation because the chert and other pieces in the residuary clay are more or less etched and are rough polished anyway.

The transportation of chert fragments from lower to higher level might prove the existence of glaciers, but a place was sought in vain where a glacier must necessarily have ascended. The "Freeport gravel"* was found however on low hills but still far above the flood plain of the river. This brown gravel if truly an ancient deep-lying river gravel, as Hershey

*Hershey (1897): AM. GEOLOGIST, vol. XIX, p. 207.

considers it to be, has been scattered high above its original bed in the "driftless area," the same as at Freeport in the northern drift. Taking for example the railway cutting through the Shakopee formation next south of Argyle station; there the residuary clay contains "Freeport gravel," lighter colored chert from the Galena (Trenton), blocks of Saint Peter sandstone, and common and oölitic chert from the Shakopee formation itself. The chert fragments in the clay may be explained as residuary debris from higher although in part no longer adjacent limestone; except the "Freeport gravel" which seemingly has *ascended.*

Mr. Hershey's theory of the "Freeport gravel" harmonizes with my own observations in that the red-brown chert has been seen in the valleys only, and inasmuch as it is scattered back upon the slopes above the river's plain and beyond where the river's bed could have been at any stage of its development, it is necessary to assume that in the "driftless area," too, the "Freeport gravel" pebbles have been again transported by glaciers. Much depends upon the future determination of the "Freeport gravel" here referred to, in the "driftless area."

Deposits not covered by the undisturbed loess loam I have neglected to describe although some of them could be of glacial origin, as for example the boulders at Jonesdale below Dodgeville. There upon the west side of a ridge the south end of which forms a high, steep bluff over the river opposite the mill, is found a heap of rounded sandstone boulders one to twelve feet in diameter, covering an area fifty by fifty feet, about twenty feet deep, and scattering up and down the slope but not extending back along the exposed side of the hill, in the direction from which they would have been transported by a glacier. They are probably boulders of disintegration, pushed from their resting places along the side of the hill and left piled in a heap. The corresponding southeast side of the same ridge shows no similar accumulation, but near the top are boulders of disintegration in place, nearly covered by sand and vegetation, which the heaped-up boulders are not. J. D. Whitney, who first called the "lead region" "driftless," observed a similar occurrence of boulders in the midst of the area. He writes:*

*Geology of Wisconsin, vol. I, 1861, p. 137.

"We have already in the preceding pages fully set forth the fact of the absence of boulders or transported materials over almost the entire area of the lead region. A single exceptional case has, however, been noticed, which is of great interest, and in regard to which it is difficult to offer a satisfactory explanation. The locality to which we here refer is one near Mineral Point, a little to the southwest of the Dreadnaught diggings. Here, between two small affluents of the Legate branch, on a ridge of Galena limestone, and at an elevation of about 125 feet above the sandstone, which is exposed at the base of the bluff or ridge something over a quarter of a mile distant to the west, is a group of loose blocks of sandstone, - - There can be no doubt that these masses of sandstone have been raised either artificially or by natural means above their original place of deposit; a circumstance which would be of easy explanation, if the drift had ever swept over this region." (P. 239).

The boulders are further described as angular, and as based several feet below the surface.

How much evidence of glaciation in the "driftless area" may be found by closer study, is not safely predicted. N. H. Winchell in his description of Houston county, Minnesota, which is in the western part of the "driftless area," says:

"There is to be seen occasionally a local drift, or debris derived from the rock of the country round about, and this sometimes has a deceitful resemblance to true northern drift, yet it can always be distinguished from it on examination."*

There may be beneath the mantle of loess-loam very widespread evidence of glaciation. Of course no gigantic moraines like those of the enormous northern drift need be expected and I think no great planing of the surface of the subjacent rocks should be a necessary result. "The differences between adjoining glaciated and non-glaciated topographies are apparently due less to glacial filing down of prominences than to grading up of depressions."†

I formerly had the good fortune of often accompanying Prof. G. Steinmann of Freiburg, Baden, in his field work on the loess and glacial deposits, and beheld, almost in amazement, the great skill with which decisive evidence of glaciation was often elaborated. I have not been able in my observation of Pleistocene deposits to use nearly so great skill, nor have there been time and facilities at my disposal for a satisfactory investigation of the "driftless area." A few things are however

*Final Rep. Geol. Nat. Hist. Sur. Minn., vol. I, p. 227, 1884.

†Chamberlin and Salisbury, op. cit. p. 207.

very plainly seen, which, if one can correctly interpret, reveal others more clearly. And since it might not occur in a long time that any glacialist should see and associate together the phenomena which I have fortunately observed, since they lie widely scattered, and in another sense are a little outside the line of generally noticed phenomena of our northwestern drift, I have ventured to write briefly of them.

EDITORIAL COMMENT.

The Close of the Twentieth Volume.

The American Geologist, established January, 1888, completes a record of ten years with the issue of this number. No previous ten years of American geology have witnessed more rapid progress, marked by more important events. In no previous ten years has geological science spread over a wider scope or occupied more advanced positions in the activities of the day. Its ways and means of self-propagation are multiplied and the efforts of its agents are more effective than ever before. With the spread of geological science, and perhaps because of it, at least commensurate with it, has been a revival of everything that springs from a knowledge of the earth, and particularly of mining and mining schools, of geological surveys and geological literature. At the present time it is probably not rash to affirm that as many pages of geological literature are disseminated in the United States in one year as were disseminated in ten years prior to the geological renaissance. The dawn of this revival was due largely to Hayden and the survey that he established. It was brightened by Cook and by Wheeler, and was fully recognized when Powell energized the United States geological survey. This great central power has electrified and aroused into action the dormant geological possibilities of the nation and its example and its results have been influential in the remotest corners of the earth. Moving slowly, like all great and powerful actors, it has accumulated momentum as time has passed, and its last ten years are its best.

It is not possible to specify, at this time, any of the great direct results of this organization, but many of its indirect re-

sults are seen in the revival of geological science already alluded to. Geological societies, surveys and journals have multiplied. Nearly every educational centre, if not every important educational institution in the land has its own means of publishing its geological researches. The earth was never probed so thoroughly, and its secrets discovered so rapidly as to-day.

With the present rapid scientific and intellectural development in the United States and in the world is a promise of greater progress in the future. We may expect reasonably that the movement now under way will not be checked till the utmost bound of the capacity of human progress is reached. We will not say that bound is in the infinite distance, but we are satisfied that it is as yet far ahead of us. The record of the years and centuries that will intervene will be marked by many failures as well as by victories, but at last truth only will reign, truth wrenched from nature in its highest expression, based on scientific research and established and perpetuated by the zeal and often by the self-sacrifice of its votaries. Among these votaries the geologist, the astronomer, the chemist and the physicist of every name, who contributes to the general advance, will occupy no mean rank.

The AMERICAN GEOLOGIST has taken part, during the past ten years, in this movement, and has aided it so far as its editors have had opportunity, and so far as their numerous official duties would permit. In this they have been encouraged during the five years last passed as during the previous five, by the cheerful assistance of numerous fellow-geologists who have tendered their papers for publication, and who have otherwise assisted them in maintaining the journal. To these the editors wish to express their thanks.

In the last ten volumes of the GEOLOGIST, two hundred and twenty-seven contributed articles have been published, not the product of the editors. One hundred articles have been contributed by the editors, as well as sixty-six articles of "Editorial Comment;" and there have been described sixty-seven new species and genera. This takes no account of "Correspondence" nor of "Reviews."

The editors can make no promises for the future, other than that which is deducible from the past. On that basis

they confidently expect the same friendly cooperation, and they expect to render the same or better service to American geology. N. H. W.

THE TACONIC ACCORDING TO RENEVIER.

Following is Renevier's reason for not adopting the advice of Lapworth as to the use of the term Taconic in his lately published *Chronographe géologique*, to which attention was called in the AMERICAN GEOLOGIST last month:

> *Géorgien.* C'est l'age le plus ancien, dans lequel le vie organique soit certaine et incontestée, mais la faune en est peu abondante et imparfaitement connue. La fréquence relative de pistes d'annélides, lui avait fait donner le nom de Annélidien. M. Lapworth vondrait appliquer à cet étage l'ancien nom Americain de Taconien, mais ce terme serait une source de confusion, M. Walcott* affirme en effet qu'il n'y a pas trace de fossiles de la faune primordiale dans le Taconic range; donc le type est fautif. D'autre part le nom de Taconien a été revendiqué pour la sério entière du Cambrien, par M. Marcou et par d'autres. Il manquerait absolument de précision pour désigner l'une des étages.

It will be seen that the decision against the use of the term Taconic was based on the statement of Mr. Walcott to the effect that in the Taconic range there is not known any trace of primordial fossils. The writer has considered this statement of Mr. Walcott in earlier volumes of the GEOLOGIST† on two occasions.

In the first place it should be noted that this remark of Mr. Walcott was not published in the Bulletin of the U. S. Geological Survey (No. 81) to which M. Renevier refers for authority, at least the writer is not able to find it there, but in an *ad captandum* argument published in the American Journal of Science just prior to the meeting of the London session of the International Congress of Geologists.‡ Immediately after its publication this statement was analyzed (AM. GEOL., vol. II, p. 221) and it was confronted with another quotation from Mr. Walcott's writing, in which he affirmed that he had found primordial fossils at over one hundred lo-

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*Bull. 81, U. S. Geol. Survey.

†Vol. II, pp. 220-222, 1888. Vol. VI, p. 247, 1890: What constitutes the Taconic range of mountains?

‡*Op. cit.*, vol. XXXV (3), p. 394. "The name is inapplicable. The Taconic range, from which the Taconic system was named, is not known to contain a fossil of the first fauna, or a formation that contains one elsewhere."

calities in the typical Taconic area, in a formation 14,000 feet in thickness. In connection with this analysis it was shown that many ranges, and hills somewhat isolated from the main range, were to be included in the Taconic range and that these had not yet been examined; and hence that it was too broad an inference from a slight examination to exclude the Taconic system from the region. This was written on the assumption that Mr. Walcott knew what and where the Taconic range of mountains was. But it appears that he spoke inadvertently, or that he actually did not know where the Taconic mountains lie.

On further examination by the writer into the literature of the Taconic mountains, this great mistake, so lamentable in its immediate results, was discovered and he called attention to the subject in an editorial in the GEOLOGIST, of which the following is a copy:*

WHAT CONSTITUTES THE TACONIC RANGE OF MOUNTAINS.

Dr. Asa Fitch describes the Taconic mountains in the following words: Runs along the east line of this county, immediately on the Vermont side of that line. From Mt. Anthony in Bennington, it passes through Spruce (or West) mountain, Red, Equinox, Bear, Antonio, Rupert and Pawlet (two names given to one long mountain) to Haystack east of Granville village. (HISTORICAL, TOPOGRAPHICAL AND AGRICULTURAL SURVEY OF THE COUNTY OF WASHINGTON, 1849, p. 936.)

Prof. J. D. Dana describes the Taconic range of mountains in the following words, so far as they exist in Vermont: This great slate belt extends from Weybridge on the north to the southwestern corner of the state, widening southward and spreading into the state of New York. The part south of Brandon has been called the Taconic range of mountains, it being properly a continuation of the Taconic range of Massachusetts. [*Am. Jour, Sci.* (3) XIII, 336, 1877.]

Geologically these hills consist, according to Mr. C. D. Walcott's geological map of the Taconic region, of "Cambrian" formations, *i. e.* of Taconic or primordial strata. [See his map accompanying his papers on THE TACONIC SYSTEM OF EMMONS AND THE USE OF THE NAME TACONIC IN GEOLOGIC NOMENCLATURE. *Am. Jour. Sci.* (3) XXXV.] He also says: Fossils occur more or less abundantly at over 100 localities as now known to me within the typical Taconic area, and they are distributed at various horizons throughout the 14,000 feet or more of strata referred to this terrane. [*Am. Jour. Sci.* (3) XXXV, 242.]

This is a direct and complete verification of the claims of Dr. Emmons in the establishment of the Taconic system on the rocks of the Taconic mountains.

*AM. GEOLOGIST, vol VI, p. 274.

This statement was accompanied by a plate representing photographed reproductions of maps of (1) the Taconic mountains in Vermont according to Fitch, Emmons, Hitchcock and Dana, (2) The central state belt, or "Hudson River" slates, according to Wing and Dana in 1877, in Rutland county, and (3) The Georgia formation, according to C. D. Walcott in 1888 in southern Vermont. These maps and their designations *are applied by their authors to the same identical area in Vermont.* Therefore, according to Mr. Walcott, there are over 100 localities in the Taconic mountains where primordial fossils have been discovered by him.

But the mistake (?) had produced its designed effect. It prevented the favorable action of the London Congress on the report of the American committee recommending the term Taconic for the Lower Cambrian, and it still has its effect in preventing M. Renevier from considering favorably the opinion of Prof. Lapworth—an opinion which is gaining constantly the hearty concurrence of geologists, and which will ultimately be universally approved.

The fact is, Mr. Walcott was favorably disposed, as he says himself, until the fall of 1887, toward the adoption of the term Taconic, and he gave an argument for its use, recommending it to the American committee in his first communication. This state of mind continued as long as he was a candidate for election to that committee at the instance of the director of the United States geological survey. When the committee failed to elect him, he withdrew hastily his report and refused to substitute another, and after a few weeks in the region of Mts. Eolus and Anthony (which are southeastern spurs of the Taconic region, but not correctly included in the Taconic range, composed of Lower Silurian strata), he hurriedly drafted his papers and map published in the March, April and May numbers of the American Journal of Science, 1888, contradicting his former views and strongly denouncing the Taconic system and its author, without having discovered a single new fact that bore even remotely on the Taconic mountains or the Taconic system. The world has been hoodwinked by such tactics as this, ever since the Taconic system was annonnced. How long, oh, how long! N. H. W.

RECENT PUBLICATIONS.

I. Government and State Reports.

U. S. Geol. Survey, Bull. 149, 152 pp., 1897. Bibliography and index of North American geology, paleontology, petrology and mineralogy for the year 1896, F. B. Weeks.

Iowa Geol. Survey, vol. 7, Ann. Rept. for 1896, 555 pp., 11 plates, 11 maps, 1897. Geology of Johnson county, Samuel Calvin; Geology of Cerro Gordo county, Samuel Calvin; Geology of Marshall county, S. W. Beyer: Geology of Polk county, H. F. Bain: Geology of Guthrie county, H. F. Bain; Geology of Madison county, J. L. Tilton and H. F. Bain.

Geol. Survey of Georgia, Bull. 5-A, 101 pp.. 3 pls., 1896. A preliminary report on part of the phosphates and marls of Georgia, S. W. McCallie.

II. Proceedings of Scientific Societies.

Hist. and Sci. Soc. of Manitoba, Trans. no. 49, 17 pp., Feb. 23, 1897. The Lake of the Woods, its history, geology, mining and manufacturing, Geo. Bryce.

Calif. Acad. Sci., Proc., ser. 3, Geol., vol. 1, no. 3, pp. 105-128, pls. 13-15, Oct. 16, 1897. The development of Glyphioceras and the phylogeny of the Glyphioceratidæ, J. P. Smith.

Amer. Soc. Civil Eng., Proc., vol. 23, no. 8, Oct., 1897. Geology in its relation to topography, J. C. Branner.

Acad. Nat. Sci., Phila., Proc., 1897, pt. 2. Patagonia Tertiary fossils, H. A. Pilsbry; Scalpellum and Balanus from Texas, H. A. Pilsbry.

III. Papers in Scientific Journals.

Science, Oct. 15: The easternmost volcanoes of the United States, R. T. Hill.

Ibid., Oct. 22: Is the Denver formation lacustrine or fluviatile, W. M. Davis.

Ibid. Oct. 29: Special explorations of the implement-bearing deposits on the Lalor farm, Trenton, N. J.. G. F. Wright: A new method of synchronizing strata, C. R. Keyes; Current notes on physiography, W. M. Davis; Lewis on the diamond, G. F. Becker; Note on the easternmost volcanoes of the United States, Jules Marcou; Glacial striæ, A. G. Rau.

Ibid., Nov. 5: The Geological Congress at St. Petersburg, J. J. Stevenson: A new investigation of man's antiquity at Trenton, H. C. Mercer and Arthur Hollick; Geology and geography at the A. A. A. S., C. H. Smyth, Jr.: Geological Society of America, C. H. Smyth, Jr.

Ibid, Nov. 12: Current notes on physiography, W. M. Davis.

School of Mines Quart., vol. 18, no. 4, July, 1897. An introduction to the study and experimental determination of the character of crystals, A. J. Moses.

Amer. Jour. Sci,, Nov. Geology of southern Patagonia, J. B. Hatcher; Some of the large oysters of Patagonia, A. E Ortmann; Former extension of the Appalachians across Mississippi, Louisiana and Texas,

J. C. Branner: Some features of pre-Glacial drainage in Michigan, E. H. Mudge.

IV. Excerpts and Individual Publications.

The mineral wealth of Canada, a guide for students of economic geology, Arthur B. Willmott. vi and 201 pp.; Wm. Briggs, Toronto, 1897.

On the continental elevation of the Glacial epoch, J. W. Spencer. British A. A. S., Sec. C. Toronto, 1897; 2 pp.

Geology of Polk county (Iowa), H. F. Bain. Iowa Geol. Survey, vol. 7, pp. 263-412, pls. 7-9, 2 maps, 1897.

Geology of Johnson county (Iowa), Samuel Calvin. Ibid., pp. 33-116, pls. 3-4, 2 maps, 1897.

On the occurrence of fossil fishes in the Devonian of Iowa, C. R. Eastman. Ibid., pp. 108-116, pl. 4, 1897.

Our local geology, W. H. Barris. Proc. Davenport Acad. Nat. Sci., vol. 7, 19 pp., 1897.

The Batesville sandstone of Arkansas, Stuart Weller. Trans. N. Y. Acad. Sci., 1897, pp. 251-282, pls. 19-21.

V. Proceedings of Scientific Laboratories, etc.

Mus. Comp. Zool., Bull., vol. 31, no. 1, pp. 19-44, pls. 1-5. Oct., 1897. Contributions to the morphology of the Turbellaria (II). W. M. Woodworth.

CORRESPONDENCE.

THE SEVENTH INTERNATIONAL CONGRESS OF GEOLOGISTS. The last Congress held in St. Petersburg was cast in such heroic proportions and carried out with such consummate skill that it easily stands out as a colossus, overshadowing all the preceding six, and its description must follow one of two directions: either a general direction, which seeks to convey the aims and results of the entire meeting as a whole; or the detailed description of its many interesting parts, including, of course, in this idea the excursions undertaken before, during, and after the regular business sessions. These latter, indeed, so far as relates to the consideration of business and the adoption of resolutions to govern the method of formulating the results of the researches of the world's geologists formed little more than a name and excuse for the gathering. Here again the idea, more or less developed at previous sessions, of presenting special collections of cartography, publications, and specimens, was so largely extended that the hall of display was the equal of many museums in the number and variety of objects, and the superior of most museums in the present interest of the objects displayed.

The discussions were neither better nor worse than those of antecedent sessions, though perhaps their hollow character as a means of establishing anything was never more apparent. At the general sessions, or those at which the vote expressing the sense of the Congress was taken, it was always evident that the nature of the vote had been

determined previously at a meeting of the council; and at the council meeting it was evident that the nature of the vote had been decided beforehand by the one or two members always composing, of course with the officers of the bureau, a sort of steering committee. In some cases where it was to be feared that there might be opposing views and a doubtful result, the presiding officer, in stating the question on which the ayes and noes were to be demanded, held up his own hand when asking for an affirmative vote, in this way—that there might be no mistake. In other cases it was "assumed;" if no objection were made, that the proposition was accepted. Indeed a few decisions were taken "unanimously" in a direction opposite to that of the conviction of the majority present, "so as to avoid lack of harmony," as our diplomatic Italian ex-president and general helmsman put it. But this absurdity is inherent in the system, and cannot be altered so long as future sessions attempt so much in so short a time. With all the distractions surrounding the late meeting no proper and serious debate was possible either in council or general session, and the question was either decided at once as the steering committee wished, or it was adjourned, or put out of the way summarily under rule twenty eleven. Such was the fate of the resolution passed unanimously at the Zürich session by both council and general session, requiring the late bureau to formulate some rule which would define the qualifications of a member and those of a delegate (if both terms were to be used). The bureau found this an unpleasant task, it is to be presumed, for it ignored the subject altogether. It would seem wise, if the taking counsel together of experienced geologists is to be continued, that there should be certain sessions of this Congress without excursions or other distractions at least during the day time. The problems with which such a body has to deal should be clearly presented, divested of superfluous matter, and really proposed and debated by those best qualified to do this.

Even if no decision were arrived at such a debate would pave the way for a future decision; and if properly reported, become part of the most valuable literature pertaining to the particular question.

On Sunday, the 17 (29) August, 1897, in the upper hall of the zoological museum of the Academy of Sciences, at 10 a. m., the members of the Council of Zürich then present in St. Petersburg, having been convoked, the president, M. Karpinsky, welcomed them. The bureau of the St. Petersburg session was then constituted by the election of

Honorary President, James Hall (former president).

Former Presidents, Capellini, Renevier.

President, Karpinsky.

General Secretaries, Tschernyschew, v. Vogdt.

Vice Presidents.

Germany, Von Richthofen, H. Credner, V. Zittel; *Argentina*, Berg; *Austria-Hungary*, Tietze, Böckh; *Belgium*, Mourlon; *Bulgaria*, Zlatarski; *Canada*, La Flamme; *Denmark*, Ussing; *Spain*, Cortazar; *United States*, Marsh, Emerson, Frazer, Emmons; *France*, Gaudry, Bertrand, Ch. Barrois; *Great Britain*, A. Geikie, Hughes, Murray; *Italy*, Cochi,

Pellati; *Japan*, Kochibe; *Mexico*, Aguilera; *Holland*, Martin; *Portugal*, Mendes-Guerreiro; *Roumania*, Stefanescu; *Russia*, Inostrantzew, Nikitin, Stuckenberg, Sederholm, Lagorio. Fr. Schmidt; *Sweden*, Nathorst, Torell; *Norway*, Brögger, Reusch; *Servia*, Zujovic; *Switzerland*, Heim.

Secretaries.

Lœwinson-Lessing (Russia), Boule (France), Belinfante (Great Britain), Lugeon (Switzerland), J. Walther (Germany), Meli (Italy), de Margerie (France).

Upon organization it was decided that French shall be the official language of the Congress for business, the discussions which could not be made in French should be translated. Scientific communications may be made in French or German without being translated. The volumes of the Congress will be published generally in French, but the scientific works in the language of the manuscript. It was decided that 'the members of the Congress taking part in the discussions should deposit with the secretary immediately after the session a copy of their remarks.

Wednesday, Aug. 20, was selected as the date of the council session at which the choice of the next place of meeting of the Congress should be decided. It was decided to divide the time of the Congress as follows: Monday—General Geology. Wednesday—Petrography, Mineralogy and Applied Geology. Friday—Stratigraphy and Paleontology. Saturday—Stratigraphy and Paleontology.

At 1:30 p. m. the session of the Congress was formally opened in the grand hall of the zoological museum of the Academy of Sciences by his Imperial Highness, the grand duke Constantine Constantinovitch, the honorary president, and by her Imperial Highness, the princess of Oldenbourg, president of the Imperial Society of Mineralogy.

The honorary president read a telegram from the grand duke Alexander Mikhailovitch. The Minister of Agriculture and Domain then read an address of welcome. M. le senator Prof. Capellini then replied as the oldest ex-president. M. Renevier, last president, then put the names of the bureau, proposed by the council, to vote, and the Congress elected them. He then turned over the presidency to M. Karpinsky.

M. Karpinsky then read his address and was followed by M. Tschernischew in a detailed report of the labors of the committee on organization.

Monday, Aug. 18 (30), 1897, the general session of the Congress was opened at 3:30 p. m., in the grand hall, and M. v. Richthofen, who presided, announced the very sad and sudden death of Dr. Spendiarow, who had taken part in the Ural excursion and was universally popular.

M. Meunier exhibited an apparatus whereby the great lines and, to some extent, the details, of the organic structure of Europe could be reproduced by allowing a rubber hemisphere covered by a thick coat of plaster to contract. M. Sacco read an essay on the "Origin of the Earth." M. Prinz read a communication on the experimental reproduction of the great terrestrial reliefs. A communication of M. Marsdon Mansdon on the "Evolution of Climates," was presented by the

president and read by title. M. Martin presented a memoir in German on the "Geologie des Moluques." MM. Forel and Upham spoke on the subject of glaciers. M. Lindvall made a communication on the causes of the glacial period.

Wednesday, Aug. 20 (Sept. 1), 1897, at 9 a. m., in the Council hall, M. Renevier proposes to elect M. Hauchecorne president of the committee on the map of Europe in place of M. Beyrich, deceased, and to add M. Beyschlag to the committee. It was decided that the report of the committee should be presented to-day. M. Karpinsky proposes to name a committee to consider the principles necessary to the chronological classification of the sedimentary rocks. It is decided to name them at the next session. M. Gaudry presents the invitation of French geologists to the Congress to meet in Paris in 1900. M. Heim thought the distractions of the world's fair in that year and place would hamper the work of the Congress. M. Emmons, in the name of *some* of his American colleagues, offered the following resolution: "That in future the quality of member of the Congress be reserved for persons whose candidacy shall have been approved by the principal geological societies or institutions of the country to which they belong." On motion of M. Mendes Guerreiro the council decided to separate the questions of the place of meeting and the limitation of the admissions. M. Karpinsky put M. Gaudry's proposition to vote. M. Tietze states that the Austrian geologists have been charged with inviting the Congress to hold the 9th session in Vienna. This invitation was accepted (?) unanimously. The further discussion of the limitation of the privileges of membership is postponed.

M. Karpinsky proposes M. Bertrand to preside at the morning session of the Congress and M. Groth at that of the afternoon. Agreed to. M. Walther in the name of several members of the Congress reads the proposition for the establishment of an international floating institute. The order of the day for the general session is then adopted.

General Session. Wednesday, Aug. 20, (Sept. 1). 1897, 11:15 a. m., Mr. Marcel Bertrand presiding.

M. Fallot invites the University professors to come in numbers to Bordeaux next year May 19 and 21 to take part in an international Congress of superior instruction.

M. Renevier speaks of the geological map of Europe and M. Beyschlag reads its report.

The order of the day is then taken up by a discussion of the terms of the articles by MM. Bitner and Frech modified and condensed by MM. Karpinsky and Tschernyschew.

I. "The introduction of a new stratigraphical term should be based on well determined scientific need and occcasioned by peremptory reasons. Every new appellation should be accompanied by a clear batrological and paleontological characteristic of the deposits to which it is applied. At the same time it ought to be founded on the evidences not of a single section but over a more or less considerable space." MM. Renevier, Depéret, Mourlon, Grossouvre, and Tschernyschew debate the

proposition which is adopted with the addition of the words "in international nomenclature" after the word term in the first line.

II. "Appellations applied to a terrane in a certain determined sense cannot be employed in any other sense." Adopted without discussion.

III. "The date of the publication shall decide the priority of stratigraphic names given to the same series of beds." Discussed by Mayer-Eymar, Bertrand, and Depéret and finally adopted.

IV. "For the small stratigraphic divisions sufficiently well characterized paleontologically, in case of the creation of new names it is preferable to take for a basis their most important paleontological peculiarities."

"Geographic or other names should not be employed except for sections of a certain importance enclosing several paleontological horizons, or when the terrane cannot be characterized paleontologically."

Discussed by Renevier, Frech, Tietze, Mourlon, Mayer-Eymar, Pavlow, Diener, and Depéret and finally adopted.

A proposition of M. Frech which follows was referred to the commission for further consideration.

"It would be desirable for the divisions of the systems in which there are not familiar names such as "Dogger," "Lias," etc., to introduce the prefixes paleo, mezo, and neo."

V. "So far as concerns the various stratigraphical terms which exist in the literature, it would be desirable that the terms designating sections or series should be replaced by the words upper, middle, and lower." (This article was referred back to the committee.)

VI. "When a term given to a whole series of beds should be restricted to only a part of these beds, it should not be preserved except for the beds best characterized paleontologically."

After discussion by Tschernyschew, Mourlon, Renevier, and Pavlow, it was referred back to the committee for further consideration.

VII. "Names badly constructed from an etymological point of view are to be corrected without excluding them on that account from the domain of the science. Adopted without discussion.

Meeting of Council, Friday, Aug. 22, (Sept. 3), 1897.

The session is opened at 9:15 a. m., M. Karpinsky in the chair.

A letter from M. Gümbel of Münich read and the council decides to send telegrams of regret at their absence to MM. Gümbel and Süess. The president presented to the council in the name of M. Richard two pamphlets 1) On the mineral wealth of Roumania, 2) On petroleum. The nomination of an international committee for the unification of nomenclature being taken up after discussion by MM. Renevier, Capellini, and others it is decided to name two classes of members on the committee, viz: the effective and the consultative.

The following members were then agreed to:

Effective Members. Barrois. Capellini, Hughes, Renevier. Tietze, Tschernyschew, H. Williams, v. Zittel.

Consultative Members. Choffat, Clark, Cortazar, Davy, Dawson,

Depéret, Frech, Griesback, Karpinsky, Keyser, de Lapparent, Martin, Mayer-Eymar, Nathorst, Nikitin, Stefanescu. De-Stefani, Taramelli, Uhlig, Van der Broeck, Walcott, Hor. Woodward.

M. Mendes Guirrero proposed that Switzerland should be chosen as the central place of session of the commission. After discussson by v. Zittel and Capellini it was decided that the committee itself should fix the places of its meetings, having regard to the meetings of the different geological societies.

The president reads the following proposition presented by a preparatory meeting of 42 petrographers (i. e., Zirkel, Groth Cohen, Kaјkowsky, Brögger, Iddings, C. Schmidt, Geikie, Riva, Sabattini, Mattiorolo, Hogbom, Pirsson, Bakom, Lagorio, Inostranzeff, Osann, Doelter, Linck, Kroustschow, Morozévitch. Barrois, Duparc, Bäckström. Bücking, Klockman, Linck (?), Milch, Scheibe, Romberg, Ussing, Lawson, v. Calker, Wichmann. Doys, Ramsay, Hobsan, Hobbst, Rinne, Loewinson-Lessing):

"A group of members of the Congress to the number of 42 met together to discuss the question of the systematic nomenclature of rocks, transmits the following to the Congress as the unanimous opinion of its members.

"It is desirable to abandon the idea of establishing by a resolution of the Congress the principles specially applicable to the methodical classification of the rocks, in view of the extraordinarily rapid development of petrography.

"To reach the simplification of nomenclature demanded by geologists it is indispensable to define with more precision than has yet been done the general names of which the employment is necessary in the execution of the maps."

MM. Barrois, Brögger, Bertrand, Karpinsky, and Renevier discussed the statement and it was referred to the already existing committee.

M. Gaudry presented the following resolution:

"The International Geological Congress, assembled in St. Petersburg, expresses the desire that the governments of all countries establish instruction in geology and paleontology in the upper classes of the higher schools, 'lycées or gymnases.' The delegates of each country are requested to inform their respective governments of this request."

M. Capellini supports the resolution, which is unanimously adopted.

M. Loewinson-Lessing recalls that a preliminary meeting of petrographers, previously referred to, had, on the proposition of M. Brögger, expressed the desire for the formation of an international publication of petrography, devoted principally to the resumés and reports of the petrographic works of all countries, and asks the Congress to name a commission for the preliminary study of this question.

After the discussion by v. Zittel, Renevier and Brögger the council decides to lay the proposition before the general assembly. M. Karpinsky's proposition to propose to the assembly as members of the committee the following names is accepted: Barrois, Becke, Brögger, Fouqué, Geikie, Iddings, Khroustschow, Loewinson-Lessing, Michel-

Lévy, Pirrson, Rosenbusch, Teall, Tschermak, Ussing, Zirkel.

After details of the order of the meeting of the general assembly were adopted the council adjourned, M. Emmons being proposed to preside at the morning session and M. Hughes at that of the afternoon.

General Session, Friday, Aug. 22 (Sept. 3), 1897, 11 a. m.

M. Emmons presiding. Papers presented:

M. Frech, Ueber Meere und Continente der paleozoischer Aeren.

M. Bashford Dean, On the relations of the paleozoic fish faunas of Russia and North America.

Afternoon Session, 3:30 p. m.

M. Hughes presiding.

M. Makowsky presented a paper on the "Lössfunde aus der Mammuthzeit von Mähren."

M. Seeley made a communication "On fossil reptiles from the governments of Perm and Wologda," and said:

"The Russian Permian reptiles have an international interest because they are neighbors of fossil forms found in Africa, the Indies, Scotland and in the United States. This interest is augmented by the discovery of M. Amalitzky in the government of Wologda where these terrestrial reptiles are associated with plants (Glossoptera) and shells. There were, therefore, very numerous Permian lakes on the land at this epoch. The reptiles are of the order of Anomodontia, but belong to different forms in different regions. Few of the genera are common to two regions. The same is true later of the Wealden reptiles. The Anomodontia are close neighbors of Labyrinthodontia and Monotremata.

"The Deuterosaurus, and Rhopalodon, have many traits in common with the Dicynodonta and although their dentition is Theriodontes they have been separated from the Theriodonta.

"M. Amalitzky believed that the Pareiosaurus lived in the Permian of Russia since the discovery of the new species of Wologda. Perhaps deeper study will demonstrate that these fossils should be referred to new Russian genera.

"These Russian fossils show but few affinities with the Monotremata. They are nearer to the Labyrinthodontia. The Anomodontia, like the dinosaurians, contain distinct types. The deuterosaurians and the Dicynodontes form the passage to the cetiosaurians. It would be preferable to unite these types into a group rather than to place the completely monotreme Theridonta in the same group with the deuterosaurians.

"The new pareiosaurians of Russia intermediate between two groups have great affinities with the Cetiosaurus."

Saturday, Aug. 23 (Sept. 4), 1897. Council Meeting. 9:30 a. m.

M. Karpinsky in the chair.

Resumption of debate on limitation to the membership of the Congress. M. Schmidt proposes to treat the questions of the limitation to the members of the Congress, and the limitation of the participants separately.

M. Frazer submitted the following resolution:

(1) Those who announce themselves to the secretary within the period fixed and who pay their fees thall be admitted to the Congress as *associates.*

(2) The *members* of the Congress who alone shall have the rights of voting on questions proposed, of taking part in the excursions arranged for the geologists by the committee of organization, and of serving as officers and members of committees of the Congress, shall be *delegates* from well known universities or societies of natural history, or those who are personally known to the members of the committee of organization by their works.

After a discussion by Tietze, Stefanescu, Capellini, Bertrand, Pellati, Renevier and v. Zittel the motion is put and lost.

M. Schmidt offers the following: "The council expresses the wish that, the number of members of the Congress remaining unlimited, the number of participants in the excursions be limited in a manner not to hamper the task of the leaders, nor the serious study of the region traversed." After discussion by MM. Emmons, Heim, Pellati, Bertrand, M. Schmidt's proposition was adopted after elimination of the words "the number of members of the Congress remaining unlimited."

M. Barrois reads a telegram from the Geological Society of France.

M. Gaudry is selected to preside at the general assembly during the afternoon session.

Saturday, Aug. 23 (Sept. 4), 1897. General Assembly. Morning Session. 11:15 a. m.

M. Zirkel presiding.

The chair reads the list of effective members of the committee to study the question of general nomenclature. They are MM. Barrois, Capellini, Hughes, Renevier, Teitze, Tschernyschew, H. Williams, v. Zittel.

The chair read the resolution of the 42 petrographers. M. Loewinson-Lessing presented a resumé of his pamphlet "On the classification and nomenclature of the eruptive rocks." M. Ramon Adan de Yarza, Lagorio, Tschernyschew, Brögger, Duparc, Iddings, Zirkel, Renevier, and Frazer discussed the question. The chair put the question of maintaining or not the committee named at Zürich. After discussion by Renevier, Wichmann, Tschernyschew, Brögger, Barrois, and Bertrand, the general assembly decided to retain the Zürich committee by 29 ayes to 19 noes.

The consideration of the foundation of the international journal of petrography was then taken up and discussed by Karpinsky, Brögger, and Tschernyschew. The general assembly decided to appoint the committee suggested by the council (see ante), with the addition of the names K. Schmidt and Thorneborn. M. Karpinsky presented to the Congress in the name of M. Nitze, "Gold deposits of North Carolina, monazite, and monazite deposits of North Carolina."

The chair then gave the floor to M. Frazer who presented the Hayden

memorial medal for the year 1897 to the president of the Congress, M. A. P. Karpinsky.

Mr. President and Gentlemen, the members of the Geological Congress:

I am charged with a mission which is outside of the duties of a member of this Congress; but notwithstanding, it is in some sort international and allied to the object which assembled us here.

In honor of the memory of the late Dr. F. V. Hayden, his widow founded the Hayden memorial medal of which the object is each year to crown the works of him who has done the most for geology. The Academy of Natural Sciences, being the first born of similar institutions on the American continent, was naturally designated to choose the recipients. Ordinarily the choice is made in the fall, but in consequence of the session of the geological congress, it awarded the medal earlier. Since the foundation of this roll of honor in 1889 till the present time seven savants of almost as many nationalities have been chosen: of whom we have the pleasure to see among us James Hall, dean of the American geologists, senator Capellini, and Prof. von Zittel (Prof. Süess being unfortunately detained in Vienna); while all science mourns the loss of Huxley, of Daubrée and of Cope.

All these gentlemen, the dead as well as the living, have given to the decoration as much honor as they have received from it by adorning it with the lustre of their names. The Academy of Natural Sciences after the examination of all the candidacies by a special committee, adopted unanimously the name proposed and delegated me to offer the material emblem to its laureate. It is therefore as a delegate of the Academy of Natural Sciences which is, in its turn, the representative of the geologists of America, that I have the honor and pleasure of presenting the Hayden medal for 1897 to M. Alexander Petrovitch Karpinsky in recognition of the great services which he has rendered to geology, as well by his special works as by his wise administration of the geological survey of the largest empire of the world, an administration which cannot but greatly influence the studies in all countries. (Applause.)

The mission with which I am charged might properly confine itself to what I have just said, but it is impossible for me not to allude to the splendid conception and perfect execution of all that concerns the VIIth international geological congress, which eclipses not only all its predecessors, but all that has ever been attempted elsewhere for science.

The unheard of liberality of the august sovereign of all the Russias to this Congress gave the measure of the confidence which his majesty accords to M. Karpinsky and to his colleagues; while the strong support that these latter gave to the director is proof of the cordial understanding among the Russian geologists. Without this confidence and without this support the result obtained would have been impossible.

In the name of the Academy of Sciences, of American geologists, and I dare say of all the members of this Congress, I wish M. Karpinsky a happy life and one sufficiently long to enjoy all the marks of esteem that he deserves and will deserve in the future. (Hearty and long continued applause.)

M. Karpinsky, receiving the medal from the last speaker, answered thus:

M. Frazer, I am deeply touched by your words so eloquent and full of sympathy for me, my Russian colleagues, and our country. I am very much overcome by the great honor which the Academy of Natural Sciences has been willing to accord to me.

I am actually confused at being placed in the same rank with the great savants who have received before myself this mark of distinction. I beg you, Sir and very much honored colleague, to transmit to the Academy of Natural Sciences my deep and warm thanks. (Applause.)

The chair read a telegram of greeting from the Geological Society of France. Close of the morning session.

Saturday, Aug. 23 (Sept. 4), 1897. General Assembly. Afternoon Session. 3:30 p. m.

M. Gaudry presiding.

M. Frech made a communication on Continents and Paleozoic seas. M. Stefanescu spoke of the Dinotherium gigantissimum (Step.) found at Munzaté, Roumania. MM. Depéret and Gaudry discussed the paper. M. Mayer-Eymar gave a succinct exposé of the geological history of the Mediterranean basin. He gave a sketch of the upper Tertiary stages and substages from the creation of the Mediterranean basin to the end of the Dertonian or upper Miocene age. He demonstrated that to the invasion of the Mediterranean by the ocean and to the retreat of the sea are due the Dertonian, Messanian, Assian, Sicilian, and Saharian stages and their sub-stages. M. v. Koennen spoke of some stratigraphical relations in Hannover. M. Martin presented the Congress with a fasciculus of his work, "The fossils of Java based on a collection of M. R. D. M. Verbeek." M. Blake read his memoir on "The distribution of fossils not merely in zones, but also in provinces." Session closed.

General Session, Sunday, Aug. 24 (Sept. 5), 1897.

The last session on Sunday was what is called I believe in the B. A. A. S., "butter day" the day on which all the highnesses, municipalities, corporations, and individuals receive profuse thanks. On this day any doubtful question may be put through as the steering committee wishes in the general good humor and desire for harmony and for the absence of every note of disaccord which prevail. At the single session presided over by M. Capellini all were profusely thanked. A resolution of M. Frazer expressing it as the desire of the Congress that the volume of the proceedings of a given meeting should if possible be printed within two years of that meeting was unanimously adopted.

The Congress agreed to accept the gift of 10,000 roubles from the father of young Stepniow, who died under such sad circumstances, the interest to be expended for prizes under the auspices of the Congress. This was in the judgment of the writer and of several other members of the Congress a very unwise proceeding although the circumstances of the gift made it very difficult to refuse it point blank, as the bereaved

father offered this to the Congress in the same spirit that he would have offered a candle to the Virgin. The difficulty of the situation lies in the fact that the Congress is not a corporate body and there is good reason why it should never become so. The moment it acquires property, agrees to fulfill periodical duties, etc., it loses its character of a convocation of the leaders of the science at a given epoch, and becomes a mere society. As a society its chances of being hunted, captured and chained by those interested in harnessing it to their schemes is manyfold greater than when it is only a name without a local habitation or material existence except in a council named from all countries. With such a precedent it will become very difficult to refuse the gifts by which superserviceable persons with more money than importance may desire to connect themselves with a large international idea. It is to be hoped that with that innate diplomacy which the Russian has as a birthright and which the Frenchman has exercised perhaps longer than any other race, means will be found to transfer this trust to the Russian Academy of Sciences or some other Russian institution and that the Congress may be freed from its dangerous bantling. If there were not reasons enough without it this one would seem sufficient to prevent the consummation of this ill-advised plan. The existence of the Congress is a matter of conjecture from one to another of its triennial sessions. If the Congress should cease to exist what would become of the bequest. Even if it be admitted that the Congress might advise with the trustee as to the use to be made of the interest on the gift, some actual institution should be the guardian of the latter, and not the incorporeal essence of pure geological science which the Congress ought to be.

One word more in regard to the sessions. When Siemens took the pretty electrical toy of a moving little train of light tin cars as a model and made a real train which ran economically by electricity he accomplished a great deal for humanity. But when Capellini takes the old trick of the Sunday school and campmeeting of clapping hands the moment a proposition is made which he wants adopted he uses a child's toy to stifle free speech and render mature deliberation impossible. This practice is growing so objectionable that if not checked, deliberation or fair discussion will become impossible, and the proceedings a farce.

PERSIFOR FRAZER.

PERSONAL AND SCIENTIFIC NEWS.

DR. S. W. BEYER, of the Iowa Agricultural College and the Iowa Geological Survey, after having attended the sessions of the International Congress of Geologists, is spending the winter in study at Munich.

DR. ROBERT BELL, of the Canadian Geological Survey, who recently returned from an extensive exploration of the shores of Baffinland, reports a very successful trip (*Ottawa Citizen*,

Oct. 27). The northern side of Hudson strait is the south side of Baffinland, which is the third island in size in the world, surpassed only by Australia and Greenland, being 1100 miles in length. The western portion of this island along the south coast is high and rocky, rising 1000 to 2000 feet above the sea, but the eastern half of the southern coast is not mountainous, but rather low. Dr. Bell was recently elected a fellow of the Royal Society of London.

DR. FRIDTJOF NANSEN, lecturing in the United States, is overwhelmed with the cordiality of his welcome in the cities of the Northwest, and is obliged to decline most of the receptions and banquets which are tendered him. Recently at Minneapolis he gave two lectures to large audiences, English and Norwegian, and was escorted to the hall by a Norwegian torch light procession, and after the English lecture he was given a select reception by the Minnesota Academy of Natural Sciences.

Dr. E. W. CLAYPOLE, of Akron, O., is spending the winter in New Mexico.

THE STRUCTURE OF THE URALS. Dr. Persifor Frazer, in a report recently made to the Philadelphia Academy of Sciences of his late visit to St. Petersburg and excursion to the Urals, gave the following description:

"Another curious circumstance is that the Ural range is only half a range, since there is no mountainous part on the west side at all. The structure is like that in some of our mountain gorges when on climbing up from a stream level over the rough basset edges of a hill we find on arriving at the top a gently sloping arable plain, extending unbroken, as far as the eye can reach.

"This is the case with this chain throughout its entire length. Eruptive and massive, and metamorphic rocks, all ascribed by the Russian geologists to the lower Devonian or much later epochs, are found in inexplicable confusion, and the almost universal accompaniments to rock coufusion, mineral veins of great intrinsic and scientific value. Here are found the Ilmen mountains, with their marvelous minerals, some of them unique. Here are the gold and platinum placers and the gangues with these metals in place, the latter being termed proudly by the Russians an exclusively Ural element."

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TO LIBRARIANS.

Beginning with January, 1898, the GEOLOGIST will contain an alphabetical author catalogue of articles relating to the geology of North America. Each month's issue will include titles of articles received up to the 20th of the preceding month, and they will be listed in the following manner.

Fairbanks, H. W.

Oscillations of the coast of California during the Pliocene and Pleistocenee. (Amer. Geol., vol. 20, pp. 213-245, pl. 15, Oct. 1897.)

Sheets containing this catalogue will be mailed monthly to libraries or individuals at $1.00 per year provided a sufficient number of orders are received to cover the expense.

NOTICE TO CONTRIBUTORS.

Since the type setting of the GEOLOGIST will be done by machinery after December 1st, 1897, it will be necessary that articles offered for publication be prepared exactly as they are to be printed, prior to delivery to the printer. Alterations from the manuscript, when once cast into type by this process, cannot be made except at a cost of fifty cents per hour.

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